ERIE COUNTY SHORELINE WIND STUDY

FINAL REPORT

Prepared for

The New York State
Energy Research and Development Authority
Albany, New York

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ABSTRACT

In 2002, the Erie County Department of Environment and Planning was awarded funding from the New York State Energy Research and Development Authority (NYSERDA) to conduct a Shoreline Wind Study that would assess the potential for wind power generation along the Erie County shoreline through accurate wind speed measurements, and that would identify economic prospects for distributed wind generation in Western New York. The county, with assistance from Ecology and Environment, Inc. (E & E), performed the following activities: (1) identified wind monitoring sites at representative locations along the Erie County shoreline, (2) obtained the required permits, (3) installed wind monitoring equipment and measured the wind resource at each site for one project year, and (4) summarized data at quarterly intervals for analysis. The data was used to validate the New York State Wind Resource Map and to better inform stakeholders in both the public and private sectors about the potential for developing a wind-energy industry in Western New York.

The sites were selected based on criteria such as geographic distribution of monitoring locations and measurements; absence of wind flow obstacles; logistics of meteorological installation; potential size and capacity of a wind farm; public safety issues; and access to electrical transmission lines. The Shoreline Wind Study results and extrapolated mean wind speed estimates demonstrate that the Erie County shoreline is a good wind resource. In addition, the New York State Wind Resource Map commissioned by NYSERDA proved to be a useful and reliable tool for determining which locations may have development potential.

This report describes the five monitoring sites and the results of the Shoreline Wind Study; describes each site's development potential; and discusses the economic benefits of local wind energy development.

Key Words:
Shoreline; Wind Development; Renewable Energy; Wind Turbine; Wind Resource

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We also appreciate the efforts and enthusiasm of Laird Robertson, Ecology and Environment, Inc. His involvement in the early stages of this project, and his commitment to the development of wind energy in Erie County, will be remembered.

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ACRONYMS AND ABBREVIATIONS

AWEA	American Wind Energy Association
CSX	CSX Corporation
DOE	United States Department of Energy
EAF	environmental assessment form
EIS	environmental impact statement
FAA	Federal Aviation Administration
GM	General Motors Co.
IBA	important bird area
ISG	International Steel Group
kg/m^3	kilograms per cubic meter
Kw	kilowatt
LWRP	Local Waterfront Revitalization Program
m/s	meters per second
MW	megawatt
NFTA	Niagara Frontier Transportation Authority
NREL	National Renewable Energy Laboratory
NWCC	National Wind Coordinating Committee
NYPIRG	New York Public Interest Research Group
NYSDEC	New York State Department of Environmental Conservation
NYSEG	New York State Electric and Gas Co.
NYSERDA	New York State Energy Research and Development Authority
O&M	operation and maintenance
PPA	Power Purchase Agreement
PTC	Production Tax Credit
RCRA	Resource Conservation and Recovery Act
RPS	Renewable Portfolio Standard
SEQR	State Environmental Quality Review Act
Sodar	sonic detection and ranging
SPDES	State Pollutant Discharge Elimination System
SSTF	Southtowns Sewage Treatment Facility
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
WPD	wind power density

SUMMARY

In 2002, the Erie County Department of Environment and Planning was awarded funding from the New York State Energy Research and Development Authority (NYSERDA) to conduct a Shoreline Wind Study that would assess the potential for wind power generation along the Erie County shoreline through accurate wind speed measurements and that would identify economic prospects for distributed wind generation in Western New York. The county, with assistance from Ecology and Environment, Inc. (E & E), performed the following activities: (1) identified wind monitoring sites at representative locations along the Erie County shoreline, (2) obtained the required permits, (3) installed wind monitoring equipment and measured the wind resource at each site for one project year, and (4) summarized data at quarterly intervals for analysis. The data was used to validate the New York State Wind Resource Map and to better inform stakeholders in both the public and private sectors about the potential for developing a wind-energy industry in Western New York.

This report describes the results of the study and discusses the existing conditions, barriers, and opportunities of each site; the economic climate for the wind energy industry; and local permitting issues.

The five monitoring sites are located along the Lake Erie/Niagara River shoreline in the Town of Tonawanda, the City of Buffalo, the City of Lackawanna, and the Town of Hamburg, in Erie County. The sites were selected based on criteria such as absence of wind flow obstacles; logistics of meteorological installation; potential size and capacity of a wind farm; public safety issues; and access to electrical transmission lines. The geographic distribution of monitoring locations (and, therefore, measurements[1]) also was considered; sites that were farther apart from the others were ranked higher than those directly adjacent to another site. Each site is located within a predominately industrial area on parcels ranging in size from 16 to 1,100 acres. The sites are, from north to south, the General Motors property; the Niagara Frontier Transportation Authority (NFTA) site; a relatively undeveloped parcel owned by CSX Corporation (CSX); the International Steel Group (ISG) site (former Bethlehem Steel), which is a brownfield site; and the publicly owned Southtowns Sewage Treatment Facility (SSTF) property, which currently is used for regional emergency medical transport operations. Because of Federal Aviation Administration (FAA) requirements, emerging sonic detection and ranging (sodar) technology was used to monitor the wind data at the SSTF site. The NFTA site contained an existing communication tower that could be used as the measurement platform, with the goal of measuring winds at heights of approximately 100 meters above the ground, as compared with a maximum height of 50 meters at the other four locations. Co-funding from the United States Department of Energy (DOE) Tall Tower Program via its 2002 State Energy Program was provided for the NFTA site.

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[1] Distributing monitoring locations over a varied geographic area provides a more diverse and comprehensive data set, which can better characterize the wind resource on a larger stretch of the shoreline.

The wind data obtained from these sites yielded the following conclusions and observations:

- In this region, the 12-month mean wind speeds varied inversely with respect to the site distances from the lakeshore.
- Surface roughness effects (i.e., the developed nature of the sites and adjacent parcels) appeared to play a major role in determining the wind resource at each monitoring site; average wind speeds were observed to drop quickly less than 2 kilometers inland.
- The derived long-term wind speed estimates validate the predicted wind speeds modeled in the New York State Wind Resource Map.
- Forecasted energy production varied substantially across the monitoring area, with net capacity factors ranging from 31% to 37% at the coastal sites and 22% to 28% at the inland sites, depending on the site and wind turbine model.

As seen in Section 4, Table 6 (shown below), and Table 7, the Shoreline Wind Study results and extrapolated mean wind speed estimates demonstrate that the Erie County shoreline is a good wind resource. In addition, the New York State Wind Resource Map commissioned by NYSERDA proved to be a useful and reliable tool for determining which locations may have development potential.

Anticipated (Extrapolated) Long-Term Wind Speed Estimates at Typical Hub Heights

Site	Long-term mean wind speed (m/s)	65-meter hub height	80-meter hub height	100-meter hub height
NFTA	7.63 (110 m)	6.92	7.20	7.49
GM	5.41 (48.8 m)	5.81	6.11	6.45
CSX	5.76 (48.4 m)	6.13	6.41	6.72
ISG	7.10 (48.4 m)	7.48	7.75	8.06
SSTF	6.87 (60 m)	6.96	7.20	7.46

Although the wind resource is the most important factor in determining the potential for commercial wind-energy development, other factors can serve as either opportunities or barriers to development. Project financing is one important consideration. Various economic incentives can encourage the development of a wind-energy industry in New York State and along the Erie County shoreline. Economic incentives such as the federal Production Tax Credit (PTC), potential long-term power purchase agreements, and the recently adopted Renewable Portfolio Standard (RPS) can further promote the development of wind energy in New York State, providing a stable energy supply for consumers. Low-cost interconnection opportunities, local permitting requirements, wholesale electric prices in the area, and opportunities for "green" market sales also can be important.

The PTC provides a tax credit for wind-energy developers/equity owners, making it possible for wind energy to be financially competitive with other traditional forms of energy production. The study shows that the PTC is critical to development of the wind-energy industry. The PTC has been extended for projects installed through 2005. Further extensions of the PTC by Congress are anticipated but not certain. Long-term power purchase agreements (PPAs) are another way to ensure the financial viability and feasibility of a permitted wind energy project. Conversely, without a long-term PPA, there is considerable risk: projects are more difficult to finance, the price of power will increase, and reliance on fossil fuels will continue.

The RPS as currently adopted in New York State does not require PPAs but will provide long-term contracts for the above-market premium for green power. While this provides a reduction in risk that will facilitate project development and benefit New York State electric ratepayers, long-term PPAs for energy would do so even more. As a long-term commitment by the State, however, the RPS sets the stage for the development of a wind-energy industry.

The regulatory process comprises a significant portion of the pre-construction effort and is another important consideration in the development of a wind-energy industry. While there is a certain level of uncertainty associated with financing wind-energy projects, the steps prior to obtaining funding are considered the riskiest. Ultimately, the lower or higher cost of wind-generated electricity can be associated with the ease of the regulatory process. Over the last several years, approval and development of wind projects throughout New York State have involved various environmental issues, time frames, and costs. To the extent that permit-related risks can be minimized, the price of generating electricity from wind also can be reduced. Currently, none of the municipalities along the Erie County shoreline have specific provisions for wind-powered structures in their local zoning laws, and thus there is no clear path to applying for and obtaining special use permits for constructing and siting wind turbines. Developers and project applicants would benefit from consistent, specific criteria for permit applications and schedules and construction requirements, turning this perceived barrier to development into a navigable and streamlined process.

The State Environmental Quality Review (SEQR) Act is another significant consideration in developing wind farms. The SEQR process is triggered if a project may have significant environmental impacts; when state permits must be obtained prior to construction; or when the state must fund or approve the proposed project. Key issues typically relevant to wind projects are avian impacts, cultural resources, visual impacts, biological considerations, and noise. Local governmental agencies and the public largely determine the level of analysis required under SEQR. A developer can minimize risk and potentially reduce the likelihood of preparing an environmental impact statement (EIS) by fostering community acceptance; siting turbines on properties having no or few environmental issues; and being knowledgeable about science, state policy, and local permitting issues.

The potential for a site to be developed for wind power purposes also depends on such factors as land availability and potential on-site electric demand. The results of this Shoreline Wind Study demonstrate that, while some sites are more suited than others for development of utility-scale wind energy, each site's wind resources and other assets are worth pursuing. The potential feasibility of using the shoreline sites that were studied for wind-powered electrical generation is noted in Section 6, Table 8.

Section 1
INTRODUCTION

In 2002, the Erie County Department of Environment and Planning was awarded funding from the New York State Energy Research and Development Authority (NYSERDA) to conduct a Shoreline Wind Study along the Erie County shoreline. The study, which involved the collection and analysis of accurate wind speed measurements at five representative sites, was used to assess the potential for wind power generation along the Erie County shoreline, validate the New York State Wind Resource Map[2] (developed in 2000 with support from NYSERDA), and identify economic prospects for distributed wind energy projects in Western New York.

The county, with assistance from Ecology and Environment, Inc. (E & E), identified wind monitoring sites at representative locations along the Erie County shoreline; obtained required permits; installed wind monitoring equipment at each site for one project year; and summarized the measurement data at quarterly intervals for analysis. AWS Truewind, LLC (formerly AWS Scientific, Inc. and Truewind Solutions), performed the wind monitoring and data analysis.

This document describes the five monitoring sites and the results of the Shoreline Wind Study; describes each site's development potential (i.e., opportunities and barriers to development); and discusses the economic benefits of local wind energy development for developers and consumers. The goal of this report is to provide information useful to stakeholders and others interested in developing wind energy resources in Western New York. Results of the study will be disseminated to the public via the Erie County Web site and a public workshop to be held in late 2005.

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[2] See http://truewind.teamcamelot.com/NY/

Section 2
WIND MONITORING SITES

SELECTION METHODOLOGY

The Project Team compiled a list of candidate sites along the Erie County shoreline that could offer diverse opportunities for future development of wind energy projects. Brownfield, active industrial, privately held, and publicly owned sites were considered, with numerical values awarded for such criteria as absence of wind flow obstacles; logistics of meteorological installation; potential size and capacity of a wind farm; public safety issues; and access to electrical transmission lines (see Table 1). The geographic distribution of monitoring locations (and, therefore, measurements[3]) also was considered; sites that were farther apart from the others were ranked higher than those directly adjacent to another site.

The sites selected included the following: General Motors (GM) property on River Road in the Town of Tonawanda; Niagara Frontier Transportation Authority (NFTA) property in the City of Buffalo, west of Fuhrmann Boulevard; CSX Corporation (CSX) property located south of Tifft Street, just north of the CSX railroad yard; International Steel Group (ISG) property at the former Bethlehem Steel site, west of New York State Route 5; and the Southtowns Sewage Treatment Facility (SSTF), west of Lakeshore Boulevard. The NFTA site contained an existing communication tower that could be used as the measurement platform, with the goal of measuring winds at heights of approximately 100 meters above the ground, as compared with a maximum height of 50 meters at the other four locations. Co-funding from the United States Department of Energy (DOE) Tall Tower Program via its 2002 State Energy Program was provided for the NFTA site.

As shown on Figure 1, and as presented throughout this report, the sites are discussed in north to south geographical order. Each site represents various opportunities and challenges, as described below.

OPPORTUNITIES AND CHALLENGES

Although the wind resource is the most important factor in determining the potential for commercial uses of wind energy, other variables can present obstacles or opportunities to the development of this resource. The selected sites present diverse opportunities and challenges.

<u>GM Site</u>

The clean fill area at the privately owned GM site was selected for its ability to validate the modeled wind resources at the northern extent of the Lake Erie/Niagara River shoreline. The site also represents a “green manufacturing” opportunity: It has access to existing electrical transmission lines and the potential to inte-

[3] Distributing monitoring locations over a varied geographic area provides a more diverse and comprehensive data set, which can better characterize the wind resource on a larger stretch of the shoreline.

grate with nearby facilities. The area is highly secure, presenting minimal public safety issues. Barriers to its use include the presently developed nature of the site. It is occupied by commercial office buildings and surface parking lots and is bordered by the NYS I-190, which could potentially limit the number of turbines that could be constructed on the site.

NFTA Site

A publicly owned parcel, the NFTA site was selected because of its ability to provide wind measurement data at a height of approximately 100 meters. The site also met the requirements of the DOE Tall Towers program, which provides funding for monitoring activities on existing towers of 100 meters or higher. The NFTA site does not present any known constraints.

CSX (Southern Portions) Site

While both the northern and southern portions of the CSX site were considered, the northern portion presented wind flow obstacles and poor tower installation logistics. In addition, the site could be easily accessed by the public, which raised public safety concerns. Conversely, the CSX southern portion presented an opportunity to evaluate wind slightly inland from the shoreline. As the site is relatively flat, cleared, and undeveloped, it would be possible to accommodate several wind turbines.

ISG Site

ISG was initially determined to be the best overall potential site during the selection process. This former Bethlehem Steel parcel met all of the criteria outlined in Table 1. A greening brownfield, the site's industrial history, urban location, proximity to Lake Erie, and the prevailing onshore breeze presented a unique opportunity for the development of a renewable energy project that could serve as a model for other industrial areas along the shores of Lakes Erie and Ontario, as well as for wind projects in urban environments. Other assets included large tracts of land available for subdivision and the general compatibility of wind turbine development with existing and planned development activities. In addition, the site offered access to electrical transmission lines, secure entry points, and easy entry and exit for construction vehicles.

SSTF Site

While the county-owned SSTF site was a solid candidate for wind monitoring and potential turbine development, it also presented significant flaws related to existing operations. A study was conducted to evaluate the compatibility of the tower with existing Mercy Flight operations (see Appendix C for final report). An objective of the study was to assess the possibility of placing a meteorological tower on the SSTF site so as not to interfere with current and future aviation-related operations at the adjacent heliport. The final

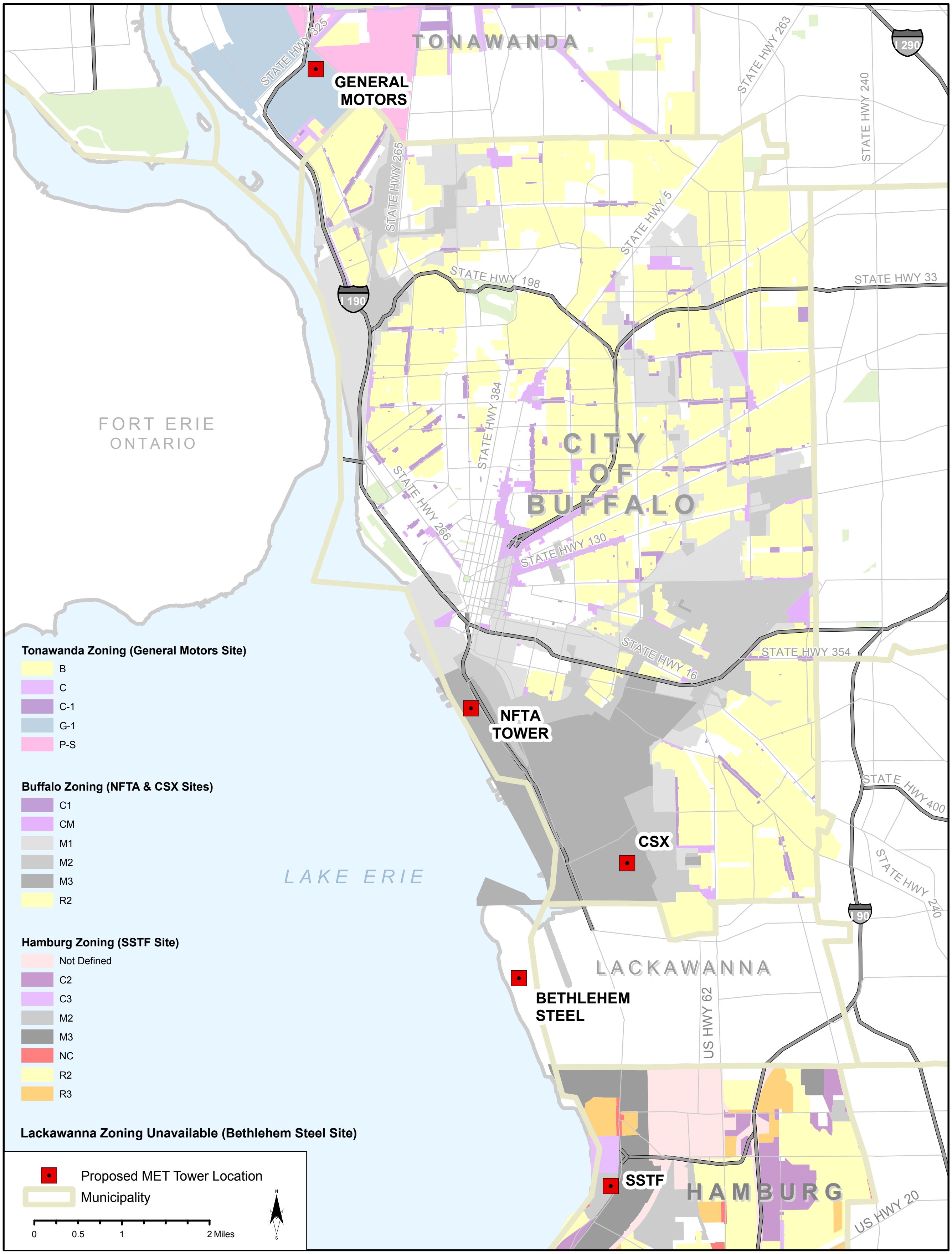

Figure 1 Shoreline Wind Study Monitoring Locations

Table 1. Site Selection Criteria

Criteria	GM (plant areas)	GM (clean fill area)	NFTA	CSX (northern portions)	CSX (southern portions)	ISG (selected location)	ISG (other locations)	Squaw Island	Southtowns Sewage Treatment Plant
Opportunity to characterize shoreline wind	1	4	5	3	4	5	3	3	4
Geographical distribution of measurements	1	5	5	3	5	5	1	5	5
Absence of wind flow obstacles	2	4	5	3	4	5	3	5	5
Orientation of available land to prevailing wind	4	4	5	5	5	5	5	3	4
Met tower installation logistics	3	5	5	1	5	5	3	3	5
Likelihood of obtaining required permits and approvals	3	5	5	3	5	5	5	2	1(helicopter)
Size of potential wind farm	~1 MW	1-5 MW	TBD	~10 MW	~10 MW	~10 MW	~10 MW	~1 MW	~1 MW
DOE Tall Tower candidate	1	1	5	1	1	1	1	1	1
Favorable public relations with development of wind site	Green Manufacturing	Green Manufacturing	Green Manufacturing	Greening Industrial	Greening Industrial	Greening Brownfield	Greening Brownfield	None	Public Green Energy
Site security	5	5	5	1	4	5	5	4	5
Public safety	5	5	5	2	4	5	5	4	5
Estimated avian effects	3	3	3	3	3	3	3	1	3
Potential public opposition	4	4	2	3	3	4	4	1	4
Access to electrical transmission lines	5	5	5	5	5	5	5	5	5
Capacity of electrical transmission lines	4	4	4	4	4	4	4	4	4

Scoring in the "Geographic Distribution of Measurements" is determined based on regional distribution.

A site is ranked lower if it is directly adjacent to another site and would, therefore, contribute little to the Geographic Distribution of Measurements.

Characteristic Scoring: 5 = Excellent, 4 = Good, 3 = Neutral, 2 = Fair, 1 = Poor

Table 1. Site Selection Criteria

Criteria	GM (plant areas)	GM (clean fill area)	NFTA	CSX (northern portions)	CSX (southern portions)	ISG (selected location)	ISG (other locations)	Squaw Island	Southtowns Sewage Treatment Plant
Potential to integrate with nearby facilities/future developments	5	5	4	2	2	5	5	4	5
Recommendation for monitoring site	1	5	5	1	5	5	3	2	4
Summary comments	Poor met tower logistics and wind flow obstacles make this a poor site.	Will validate northern extent of shoreline wind. Interested wind customer important to local manufacturing	Only shoreline tower meeting DOE Tall Towers program. Will be good data point.	Poor met tower logistics and wind flow obstacles make this a poor site.	Has good potential. Good data point for evaluating wind slightly inland from shoreline.	Meets all criteria. Best overall potential site.	Possible backup site.	Poor site because of location in major avian flyway	Good potential site if there is no conflict with Mercy flight helicopter

Scoring in the "Geographic Distribution of Measurements" is determined based on regional distribution.

A site is ranked lower if it is directly adjacent to another site and would therefore contribute little to the Geographic Distribution of Measurements.

Characteristic Scoring: 5 = Excellent, 4 = Good, 3 = Neutral, 2 = Fair, 1 = Poor

report referred to the applicable Federal Aviation Administration (FAA) guidelines for determining obstacle evaluation surfaces; provided an outline of criteria and recommendations on whether a Notice of Proposed Construction should be submitted to the FAA; and recommended that a tower be placed as far south as practicable on the SSTF property, as far away as possible from the heliport and its approach/departure corridors. Subsequently, a Notice of Proposed Construction was submitted to the FAA. Although the flight paths of the Mercy Flight helicopter were being revised at the time the Notice was submitted, it was determined that a tower could pose a safety threat to existing operations. Thus, emerging technology known as sonic detection and ranging (sodar) was used to estimate wind characteristics at this location, and the measurements were validated against those taken at the NFTA site. The sodar system measured the mean wind and wind shear profiles of the atmospheric layer within which large-scale wind turbines operate. Appendix D presents more details regarding the sodar measurements.

SITE DESCRIPTIONS AND MONITORING LOCATIONS

The selected sites are located along the Erie County shoreline in the Town of Tonawanda, the City of Buffalo, the City of Lackawanna, and the Town of Hamburg. The locations and zoning designations of each site are indicated on Figure 1. Table 2 provides additional site details, including respective site coordinates, elevations, periods of record, and anemometer heights. Appendix E presents photographs of the monitoring towers and surrounding areas.

Table 2. Monitoring Site Commissioning Information

Site Name	Coordinates	Ground Elevation (meters)	Period of Record	Anemometer Heights
GM	42° 58' 14.9" N 78° 54' 34.0" W	178	7/3/03 - 8/31/04	48.8 m, 30 m
NFTA	42° 31' 23.4" N 78° 52' 19.2" W	172	5/1/03 - 6/30/04	110 m, 59.5 m, 28.4 m
CSX	42° 50' 19.4" N 78° 50' 39.4" W	174	8/15/03 - 8/31/04	48.4 m, 30 m
ISG	42° 49' 12" N 78° 52' 6.8" W	181	8/15/03 - 8/31/04	48.4 m, 30 m
SSTF	42° 47' 6.4" N 78° 50' 56.0" W	181	11/7/03 - 12/6/03	N/A[1]

[1] Sodar was used at this site.

The installed towers included a 50-meter-tall tower constructed of 5-inch-diameter tubular steel; wind speed and direction and air temperature sensors at height of approximately 20, 40, and 50 meters; an electronic data logger with solar charger and cell phone; and a lightning grounding kit. The towers were erected on the properties no closer than 200 feet from any structures, trees, or roads, and equipment was inspected quarterly by AWS Truewind, LLC. Property locations and site characteristics and are described in more detail below.

GM (Clean Fill Area) Site

The GM property occupies 160 acres and is located on River Road in the Town of Tonawanda, near the I-190 and the Niagara River. The site is located in a General-Industrial (G-I) zoning district and is bounded by American Axle Manufacturing, Inc., Niagara Mohawk, and other privately held G-I parcels. The land use code is also industrial, i.e., manufacturing and processing. A 50-meter-high meteorological tower was installed on a landfill area at the northeast corner of GM's Tonawanda Engine Plant. The landfill rose approximately 5 meters above the surrounding ground level, with the one-story engine plant buildings located to the southwest. The tower was located southeast of a patchy area of 15-meter-high trees.

The tower was commissioned on July 3, 2003, and operated until September 1, 2004. The ground elevation was 178 meters above mean sea level (amsl), which is approximately 10 meters higher than the level of the Niagara River, which at its nearest approach is located approximately 1.5 kilometers southwest of the tower.

NFTA Site

The NFTA site is located on a relatively undeveloped, 110-acre parcel of land west of Fuhrmann Boulevard in the City of Buffalo. An additional 105 acres of NFTA-owned land are located north of the site. According to New York State Assessment Data, the site is classified as commercial and is approved for the use of piers, wharves, docks, and related facilities. It is located in the M-2 (General-Industrial) zoning district. Surrounding uses are primarily designated as vacant, commercial, or industrial, and include other NFTA-owned property, Freezer Queen Foods, Inc., and the Conrail-Buffalo Creek Rail right-of-way.

The NFTA tower was located approximately 200 meters from the Lake Erie shoreline and approximately 3.5 kilometers south of downtown Buffalo, New York. On March 28, 2003, monitoring equipment was installed at heights of 28.4 meters, 59.5 meters, and 67 meters on the existing 140-meter tower. The upper level monitoring equipment was subsequently moved up to 110 meters on May 8, 2003. The site was operated until the tower was removed in July 2004. The tower was adjacent to a large parking lot for the two-story NFTA shipping and distribution buildings located approximately 200 meters south and west of the tower. The building to the west of the tower is approximately 150 meters long and situated parallel to the north-northwest to south-southeast running shoreline; the building to the south of the tower is approximately 300 meters long and runs perpendicular to the shoreline. In general, the buildings affect the tower fetch (the distance the wind blows over) from the southeast through west prevailing wind directions.

CSX (Southern Portions) Site

The CSX site is situated on approximately 16 acres of vacant land located south of Tifft Street and immediately north of the CSX railroad yard. Although a specific New York State site classification code was unavailable for this parcel, the adjacent sites are characterized as vacant industrial. The parcel is generally grassy, with isolated trees less than 10 meters high. There are no buildings in the vicinity of the site. The parcel is located in the C-1 zoning district (Neighborhood Business District) and, because of its proximity to Lake Erie, is within the City of Buffalo Special Coastal Overlay District.

The meteorological tower was commissioned on August 15, 2003, and operated until September 1, 2004. The ground elevation was 174 meters, which is approximately 5 meters above mean lake level. Due to the hard soil and industrial landfill at the site, large concrete blocks were used to secure the tower.

ISG Site

The ISG-owned property comprises more than 1,300 acres on the former Bethlehem Steel site. The tower was sited on the 1,100-acre parcel located west of New York State Route 5, approximately 120 meters east of the lakeshore. The ground elevation (181 meters) was approximately 10 meters above mean lake level. No buildings were in the vicinity of the tower, and the surrounding area was generally devoid of vegetation due to the industrial landfill at the site. Only isolated trees less than 10 meters high were located northeast of the site.

The tower was commissioned on August 15, 2003, and operated until September 1, 2004. As was the case at CSX, large concrete blocks were used to secure the tower because of the hard soil and industrial landfill at the site.

SSTF Site

The approximately 43-acre SSTF site is located along Lake Erie, west of Lakeshore Boulevard. The county-owned property is zoned M-2 (General-Industrial) and is classified as a public service use. The site contains a county-owned and operated sewage treatment plant. The Ford Motor Company Stamping Plant is located approximately 150 meters to the east, and the Lake Erie shoreline is approximately 400 meters to the west. The site is surrounded by single-story light industrial facilities at a minimum distance of a few hundred meters. The property also is the site of a private heliport used by Mercy Flight, a regional emergency medical transport service.

Due to aviation concerns associated with the Mercy Flight heliport and landing pad, a sodar system was used to obtain wind measurement data from this site. The sodar unit was located in a field approximately 90 meters south of the SSTF and operated from November 7 to December 6, 2003. The sodar profiles obtained at the SSTF site were compared with measured and extrapolated profiles from the NFTA tower fitted with cup anemometers at heights of 28, 59, and 105 meters.

Section 3
APPLICABLE ZONING REGULATIONS AND PERMITTING ISSUES

Development in the Western New York region is guided and controlled by various land use laws and ordinances. The cities of Lackawanna and Buffalo and the towns of Tonawanda and Hamburg rely upon specific zoning ordinances as outlined in their respective charters and codes to regulate the location, construction, and use of buildings, structures, and lands. The ordinances include discussions of zoning designations, special districts, land use types, permitted uses, and exemptions.

Development of an urban wind farm is unprecedented in the United States and presents unique challenges, although a large turbine was successfully sited along the Lake Ontario shoreline in Toronto, Canada. Construction of a wind farm would necessitate compliance or compatibility with local and regional zoning regulations and permitting issues, many of which vary from one municipality to another.

FEDERAL AND STATE REGULATIONS

Development of each site would involve the same state and federal requirements encountered by rural wind projects, which are described below:

- State Environmental Quality Review Act (SEQR) compliance: In New York State, all discretionary approvals (permits) from a state agency or unit of local government require an environmental impact assessment as prescribed by SEQR. SEQR requires the identification and mitigation of significant environmental impacts of the activity being proposed or permitted. Environmental assessments are standardized by use of an Environmental Assessment Form (EAF) as a screening tool to determine impacts and their significance.

  Upon completion of the EAF, the lead agency determines the significance of an action's environmental impacts. The agency then decides whether to require an Environmental Impact Statement (EIS) and whether to hold public hearings on the proposed action. When a full EIS is required, the SEQR process can take between 12 and 18 months from beginning to end and must be conducted in concert with other permits and approvals. While only one proposed wind farm project in New York State has involved a full EIS, there is a possibility that siting a wind turbine/wind farm at any of the studied monitoring sites could require an EIS.

  The New York State Department of Environmental Conservation (NYSDEC) and the United States Fish and Wildlife Service (USFWS) are typically either involved agencies or interested parties under the SEQRA permitting process. Both agencies recommend that the developer consult with them regarding proposed projects, particularly with respect to the scoping of avian studies.

- FAA approval: The FAA requires submittal of a Notice of Proposed Construction for actions occurring in the vicinity of existing aircraft operations. If located within 1,000 feet of a heliport or runway, or if above a certain height restriction, the Notice and all applicable maps must be submitted to the regional FAA office (located in Jamaica, Queens County, New York). A response or approval of the proposed action will take approximately six to eight weeks. The SSTF site presents a challenge with respect to FAA regulations, as a proposed wind turbine could interfere with existing Mercy Flight operations. Should Mercy Flight be relocated or flight paths be revised, the site would be relatively easier to permit.

- Permits and approvals from other governmental agencies: Permits from other governmental agencies may include state (NYSDEC) or federal (U.S. Army Corps of Engineers [USACE]) wetland permits, and State Pollutant Discharge Elimination System permits (SPDES) related to stormwater runoff. If permit or other regulatory approval is required from a federal agency, or involves federal financial assistance, a consistency review by the Department of State will likely be required to determine whether the project complies with the New York State Coastal Management Program. In addition, within a community having an approved Local Waterfront Revitalization Program (LWRP), state agency actions must comply with that LWRP. The Town of Tonawanda and City of Lackawanna have approved LWRPs, and the City of Buffalo is in the final stages of completing its LWRP. Projects also are subject to review by the local Planning Board for consistency with the policies set forth in its LWRP.

  By federal regulation, the Department of State is required to notify an applicant of its decision in three months. Typically, most consistency reviews can be completed within one or two months.

LOCAL ZONING REGULATIONS AND PERMIT APPROVALS

Table 3 identifies the location of each monitoring site.

Table 3. Monitoring Site Locations

GM	Town of Tonawanda
NFTA	City of Buffalo
CSX	City of Buffalo
ISG	City of Lackawanna
SSTF	Town of Hamburg

While the SEQR process and FAA requirements are consistent for all potential projects within the region, the ease of developing a wind farm/constructing a wind turbine may vary by site based on local permit requirements, which can affect the timeline, cost, and ability to develop a project. The City of Lackawanna, for example, did not require a permit application to install the meteorological tower on the ISG site, whereas the City of Buffalo and the Town of Tonawanda required an application for a special use permit for the CSX and GM sites. Similarly, construction of a wind turbine on one site may require a more detailed site investigation while another site may not.

The permitting process is perceived to be "development friendly" if wind-powered structures are specifically addressed in local zoning law. A reasonable timeframe for approval and navigable, specific criteria for application submittal can greatly reduce cost and risk for a developer. Currently, none of the candidate municipalities in Erie County have specific provisions for wind-powered structures in their local law, which can present challenges to a first-time developer of such structures in the region.

The candidate sites are located within predominately industrial areas proximate to the Erie County shoreline. Permitted uses are generally less restrictive within designated industrial districts than in residential, commercial, or other districts. The CSX site, while industrial, is also located within a Special Coastal Review Zoning District. The site is within 1 mile of Lake Erie, requiring a restricted use permit from the City of Buffalo in addition to a building permit. While the NFTA site also is within a Special Coastal Review Zoning District, erection of monitoring equipment took place on an existing tower; thus, a permit was not required.

As with the CSX site, a potential wind development project at any of the sites would also require a special use or restricted use permit. Consistent with the application process undertaken in permitting the meteorological towers for this study, submittal of the following would likely be required:

- A site plan based on project value, size, and location;
- A permit application filed by the owner of the property or persons having a contractual interest in the property;

- Detailed site-specific information, including elevations, section profiles, evidence of site control/safety, site project construction schedule, and a list of permits required from other governmental agencies; and
- A completed EAF pursuant to SEQR.

The City of Buffalo permit review process for the CSX site required submittal of the application and site plan to the Division of Planning staff for review and recommendations for the Planning Board. A public hearing was held to help inform the Planning Board's decision, and adequate written notice of the hearing was given to the public, adjacent property owners, and the City Council. Upon review of the proposal with respect to overall impact and compatibility with surrounding properties and planned development, the Planning Board forwarded to the City Council its decision to approve the project. Other options included "approve with modifications" or "disapprove the project." When approved by the City Council, a building permit was obtained and a fee paid. The Town of Tonawanda special use permit review process was slightly different. While the Town required submittal of a site plan, a SEQR Short Form, and building permit fee, the Planning Board reviewed the application internally and did not require a public hearing, presentation, or written notice.

PERMITTING ISSUES

As mentioned above, a developer can anticipate lower costs and risk if wind-powered structures are specifically addressed in local zoning law. Currently, none of the municipalities along the Erie County shoreline have specific provisions for wind-powered structures. Developers and project applicants would benefit from consistent, specific criteria for permit applications and schedule and construction requirements, turning this perceived barrier to development into a navigable and streamlined process.

Section 4
EXISTING AND PLANNED DEVELOPMENT

GM SITE (CLEAN FILL AREA)

This active industrial site occupies approximately 160 acres. The clean fill area, located on the rear, northern portion of the site, is currently unused. As the entire GM parcel contains ongoing industrial operations, no new or alternative development is planned for the near future.

NFTA SITE

This site occupies approximately 100 acres. In September 2004, the tower was removed to accommodate future remediation activities required by NYSDEC. The land is currently unoccupied and is being remediated. Although future development scenarios have not yet been identified for this parcel, the site represents a wide variety of opportunities with no significant land use, zoning, or development constraints.

CSX SITE (SOUTHERN PORTIONS)

The CSX site occupies approximately 16 acres. The land is vacant and no known development is planned for the parcel.

ISG SITE

The ISG site occupies more than 1,300 acres, approximately 1,100 of which are west of New York State Route 5, adjacent to Lake Erie. The northern/central portion of this parcel is currently slated for remediation activities in the near future. Other planned development includes several proposals submitted to the City of Lackawanna and Erie County for active and/or passive recreational activities intended to revitalize the waterfront area.

SSTF SITE

The SSTF site occupies approximately 43 acres. The parcel is adjacent to a New York State park (Woodlawn Beach) and is the site of Mercy Flight, a regional medical emergency transport service. While the site currently presents constraints with regard to FAA requirements, Mercy Flight is being evaluated for relocation. The parcel could provide development opportunities if these operations are relocated.

Section 5
STUDY RESULTS: EVALUATION OF WIND RESOURCES

Wind monitoring activities along the Erie County shoreline resulted in the following conclusions and observations:

- Surface roughness effects (resulting from the developed nature of the sites and adjacent parcels) appeared to play a major role in determining the wind resource at each monitoring site. Average wind speeds were observed to drop quickly less than 2 kilometers inland[4].
- The wind speed estimates computed for the Shoreline Wind Study validate the predicted wind speeds modeled in the New York State Wind Resources Map (see Figure 2). The uncertainty associated with the map predictions is approximately equivalent to the uncertainty associated with the long-term wind speed estimates derived from actual wind measurements.
- Forecasted energy production varied substantially across the monitoring area, in accordance with the observed spatial wind speed profile/characteristics. The coastal sites suggest net capacity factors between 31% and 37%, depending on the site and wind turbine model (see Appendix B), while the inland sites indicated net capacity factors between 22% and 28%.

OVERVIEW OF METHODOLOGY

Each site was monitored over a 12-month period, beginning in April 2003 at the NFTA tower site and in September 2003 at the CSX, ISG, and GM sites. The sodar unit on the SSTF site operated from November 7 to December 6, 2003. The data obtained from the stations during the monitoring period were compared with the long-term wind speed conditions at the Buffalo Airport meteorological reference station. These comparisons were the basis for determining anticipated long-term wind speed conditions at the monitoring sites at the highest actual monitoring height at each site. Wind speed interpolations/extrapolations were made for typical hub heights (65 meters, 80 meters, and 100 meters) using measured wind shear values. The extrapolated long-term speeds at various likely turbine hub heights were then compared with the predictions shown in the New York State Wind Resources Map, completed at a resolution of 200 meters. The results of each phase of the analysis are described briefly below.

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[4] While surface roughness is important to determining the wind resource at a site, the restrictions on further development at the sites is not expected to be onerous. The aerodynamic effects of an obstacle such as a building or tree belt extends to twice the height of the obstruction. In order not to have an impact on the turbine, buildings and trees should be limited to a height of 20 meters (about 66 feet) within a radius of 400 meters (about 1,320 feet) around each wind turbine. This analysis assumes that each wind turbine uses an 80-meter rotor and an 80-meter tower.

SUMMARY OF WIND STATISTICS

Table 4 presents a number of important wind characteristics observed at each site, including mean wind speeds, wind power density, wind shear, and prevailing wind direction. Among the parameters detailed in Table 4 is wind power density (WPD), which provides a truer indication of a site's wind energy potential because it combines the effect of a site's wind speed frequency distribution and temporal variations in air density. Average WPD is defined as the wind power available per unit area swept by a turbine's blades. The wind power density was highest at the NFTA and ISG sites, respectively.

Table 4. 12-Month* Monitoring Site Wind Statistics Summary

Parameter	GM	NFTA	CSX	ISG
50-m Mean Wind Speed (m/s)	5.35	7.51 (110 m)	5.68	7.00
Data Recovery (%)	99.5 %	97.7 %	99.4 %	99.5 %
Prevailing Wind/Energy Direction	WSW/WSW	WSW/WSW	SW/W	WSW/WSW
Wind Shear Exponent	0.248	0.192	0.211	0.177
50-m Turbulence Intensity	0.151	0.082 (110 m)	0.144	0.089
50-m Wind Power Density (wpd/m^2)	182	578 (110 m)	256	483
Weibull Parameters (*A*/*k*)**	6.03 m/s/2.03	8.44 m/s/1.75	6.38 m/s/1.75	7.85 m/s/1.73
50-m Energy-Weighted Air Density (kg/m^3)	1.225	1.214 (110 m)	1.231	1.231

* The recording period is from 9/1/03 to 8/31/04, except for the NFTA site, which was monitored from 4/1/03 to 5/31/04. The SSTF site was measured using sodar and is not directly comparable here. SSTF results are shown in subsequent tables.

** The Weibull distribution is an analytical probability function that can be used to describe the wind speed frequency distribution or number of observations at specific wind speed values. It has two adjustable parameters (*A* and *k*) that enable it to fit a wide range of probability density functions. *A* is a scale parameter related to the mean wind speed, while *k* controls the shape of the Weibull distribution. Values of *k* typically range from 1 to 3.5, with lower values indicating a flatter distribution.

The 12-month mean wind speeds in this region varied inversely to the site distances from the shoreline. This is explained by the widespread urban and industrial development present in the onshore surrounding area. The result is an abrupt, non-uniform increase in surface roughness, which is the greatest contributing factor to the significant reduction of wind speeds within the first few kilometers onshore.

Because of the strong influence of Lake Erie on the regional climate, the regional prevailing wind (and energy) direction is from the west-southwest. CSX is the only site that does not display this exact signature, with its prevailing southwesterly direction and a westerly energy direction. The wind roses for the 12-month monitoring period are shown in Figure 3 and are discussed in more detail in Appendix E.

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L:\Buffalo\Wind_Study\mxds\Figure2_windresourcemap.mxd - 1/2005 - GIS

Source: Truewind Solutions / NYSERDA, 2001

Figure 2 Wind Resource Map
Western New York

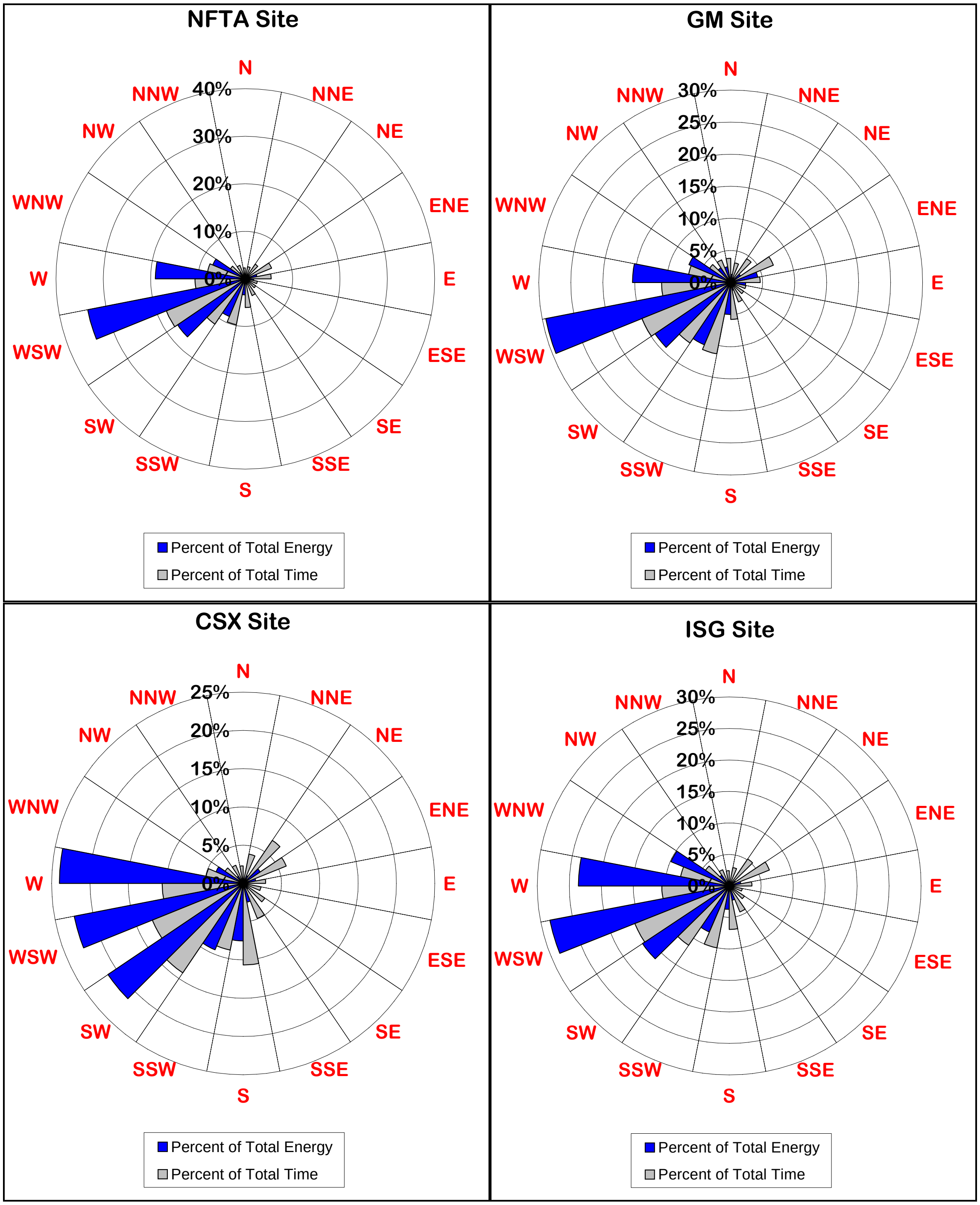

Figure 3 Monitoring Site Annual Wind Roses

The mean wind shear exponents (for speeds greater than 4 meters per second [m/s]) ranged from 0.177 to 0.248, and the turbulence intensity values ranged from 0.082 to 0.151. An inverse relationship exists between each parameter and the wind speed. This is explained by the proximity of the higher wind-speed sites (NFTA and ISG) to the shoreline, which subjects the winds to lower surface roughness “upwind fetch." Furthermore, it was observed that when Lake Erie was frozen, the wind shear dropped at the NFTA and ISG sites while remaining fairly constant at the GM and CSX sites.

A site's air density is important because the amount of energy produced by a wind turbine for a given wind speed is a function of the air density. A 10% increase or decrease in air density can change the output of a wind turbine by nearly the same percentage. As shown in the table, the energy-weight site air densities were consistent (approximately 1.23 kg/m) throughout the region. This is due to the close proximity of the sites to one another and also the uniformity of the terrain. The NFTA density appears to be much lower, but the 110 m measurement height is likely responsible as the 50 m value is approximately 1.223 kg/m^3.

Figure 4 is a plot of the monitoring sites' monthly mean wind speeds. As shown in the figure, the profiles were consistent, with the strongest winds observed in January 2004 and the lowest occurring in August 2003. This is to be expected because the strongest winds in this region normally occur between fall and early spring, when atmospheric temperature and pressure gradients are greatest. The wind speeds at each site are presented at their measurement height. Since the wind speeds at the ISG, CSX, and GM sites are quite different from each other, these are naturally graphed as distinct quantities. Since the NFTA site has wind speeds between these sites, it is convenient to list the measured height so that the wind speeds will be distinct. Diurnal and directional distributions are plotted and explained in Appendix E.

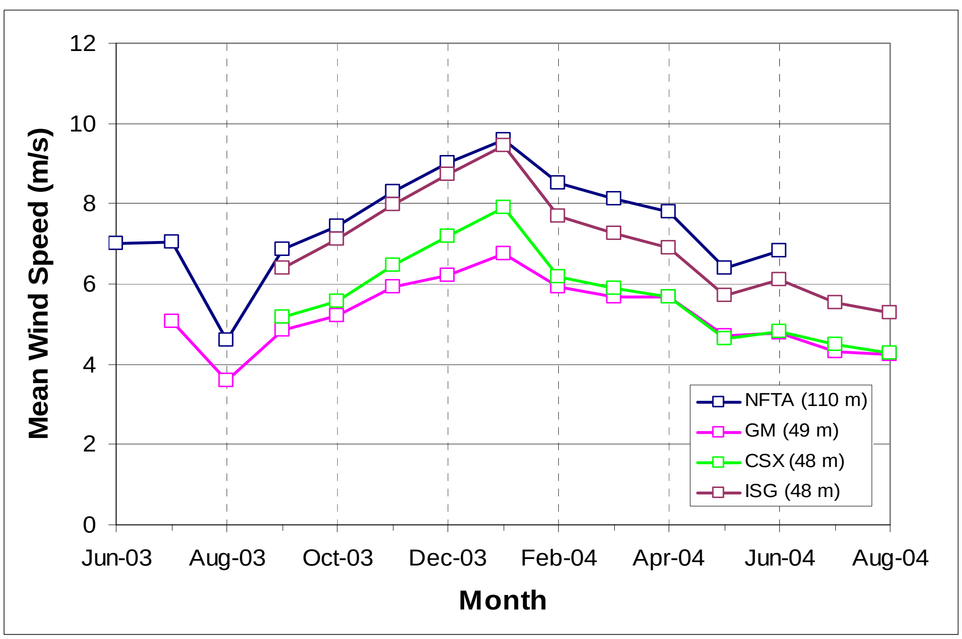

Figure 4 Monitoring Site Monthly Mean Wind Speed Distributions

LONG-TERM WIND SPEED ESTIMATE

The Buffalo-Niagara International Airport was used as a reference station because of its proximity (less than 20 kilometers away) to all of the towers. (See Appendix E for a discussion of wind speed equipment and data.) An analysis was conducted to determine the relationship between each tower and the airport and to rule out trends that would introduce potentially significant errors into the long-term adjustment of site data. The results of this analysis suggest a strong correlation between the monitoring sites and the reference station. Thus, the Buffalo-Niagara International Airport long-term mean wind speed data collected between 1996 and 2003 were used to extrapolate long-term mean wind speed estimates for each site.

Long-term mean wind speed estimates for each site are summarized in Table 5. (The methodology for this analysis is provided in Appendix E.) The SSTF sodar results also are included to show how a long-term wind speed estimate was derived for comparison with the New York State Wind Resources Map, as detailed in the subsection below. Sodar is an acoustic sounding technology that can be easily deployed at existing and proposed wind energy sites to accurately measure the boundary layer's vertical wind and turbulence structure at heights above conventional meteorological towers. Improved knowledge of the boundary layer at the heights of today's large wind turbines is essential for sound site screening, turbine selection, production prediction at hub height, and wind plant operations.

The accuracy of long-term wind speed estimates from the sodar unit were found to be similar to those for 50-m towers (± 3.5%). The accuracy of long-term wind speed estimates using sodar is dependent on the strength of the correlation to the long-term reference station. Since the correlation was excellent in this case, the accuracy of the long-terms speeds based on sodar also was excellent.

A companion report (AWS Truewind 2004) presents the results from the sodar unit. This report is included as Appendix D to this document.

Table 5. Monitoring Site Long-Term Wind Speed Estimates

Monitoring Site	Long-Term Mean Wind Speed (m/s)
NFTA	7.63 (110 m)
GM	5.41 (48.8 m)
CSX	5.76 (48.4 m)
ISG	7.10 (48.4 m)
SSTF (sodar)	6.87 (60 m)

The long-term mean wind speed estimates were used to validate the New York State Wind Resource Map (see below) and to derive long-term mean wind speed estimates for typical wind turbine hub heights (65 m, 80 m, and 100 m). These estimates are presented in Table 6 and are compared with the extrapolated long-term mean wind speeds at the actual monitoring heights. Estimates for the SSTF site (using sodar data) are also shown.

Table 6. Anticipated (Extrapolated) Long-Term Wind Speed Estimates at Typical Hub Heights

Site	Long-term mean wind speed (m/s)	65-m hub height	80-m hub height	100-m hub height
NFTA	7.63 (110 m)	6.92	7.20	7.49
GM	5.41 (48.8 m)	5.81	6.11	6.45
CSX	5.76 (48.4 m)	6.13	6.41	6.72
ISG	7.10 (48.4 m)	7.48	7.75	8.06
SSTF (sodar)	6.87 (60 m)	6.96	7.20	7.46

VALIDATION OF THE NEW YORK STATE WIND RESOURCES MAP: WESTERN NEW YORK

In 2000, a New York State Wind Resources Map was created with support from NYSERDA. Additional data and computational abilities have resulted in a revised and improved map that has been partially validated by updated data sets such as presented in this study. Table 7 illustrates the map validation statistics at 80 meters above ground, which is a typical hub height for modern wind turbines. The 2000 New York State Wind Resources Map is shown to model the wind resource with an accuracy that is comparable to actual measurements (see Figure 2).

Table 7. Comparison of Measured and Predicted Wind Speeds (at a height of 80 meters)

Site	Extrapolated Wind Speed (m/s)	200-meter Map Resolution	
		Predicted Wind Speed (m/s)	Measured Minus Predicted
NFTA	7.20	7.38	-0.18
GM	6.11	6.38	-0.27
CSX	6.41	6.82	-0.41
ISG	7.75	7.71	0.04
SSTF (sodar)	7.20	7.29	-0.09
Average (m/s):	6.93	7.12	-0.19
Average (%):			-2.7 %
Standard Deviation (m/s):			0.17

The validation statistics presented above provide confidence that the wind map can be used to provide accurate estimates of the energy production of wind plants to be located along the Erie County shoreline. Additional validation statistics are available in Appendix E.

Section 6
ECONOMIC, INSTITUTIONAL, AND REGULATORY ISSUES FOR WIND ENERGY DEVELOPMENT IN WESTERN NEW YORK

As shown in this study, winds along the Erie County shoreline are strong compared with those inland. While the wind data may indicate better wind energy resources at one site than another, other factors contribute to the development potential of a site. Local ownership scenarios, on-site use of electricity, institutional climates, grid interconnection, environmental factors, and regulatory issues play a critical role in the development of wind energy projects.

Potential development scenarios have changed dramatically in the last several years. From the beginning of the Shoreline Wind Study to the present, the following major changes have occurred:

- The federal PTC lapsed and was then reinstated, but only for projects that begin operation before the end of 2005; further extensions of the tax credit by Congress are anticipated but not certain;
- Long-term PPAs are lacking;
- The New York State RPS was adopted;
- Opportunities for selling wind power to entities engaged in “green power” marketing has increased; and
- Tax credits for using brownfields have been established, and the ownership of the former Bethlehem Steel site has changed twice.

Other significant issues to consider in siting and developing a wind turbine/farm include potential ownership scenarios, markets of wind-generated energy, avian impacts, and the changing nature of environmental permitting within New York State. These changes and issues are discussed below.

THE PRODUCTION TAX CREDIT

The federal PTC is intended to partially correct the existing tilt of the federal energy tax code, which has historically favored conventional energy technologies such as oil and coal. The credit is generally a business credit that applies to electricity generated from wind plants for sale to a utility or other electricity supplier, which then sells the electricity to consumers. The developer subtracts the value of the credit, currently at 1.8 cents per kilowatt-hour of generated electricity, from the business taxes that it would otherwise pay. The credit applies to electricity produced during the first 10 years of a wind plant’s operation and is adjusted for inflation. In December 2003, Congress allowed the wind PTC to expire. The PTC was reinstated in September 2004 and is valid until December 31, 2005. The PTC tax credit makes it possible for wind energy to be financially competitive with other traditional forms of energy production. In 2003, 1,687 megawatts (MW) of capacity were installed in the United States (American Wind Energy Association

March 10, 2004), raising the cumulative installed capacity to 6,374 MW. When the PTC lapsed in 2004, the expected cumulative installed capacity rose to only 6,436 MW. With only a partial year of the PTC in place, the expected installed new capacity in 2004 (62 MW) was only 4% of the 2003 installed new capacity[5], demonstrating that the PTC is critical to development of wind energy uses.

LONG-TERM POWER PURCHASE AGREEMENTS

The economics of wind-generated electricity differs from fossil-fuel-generated electricity. Fossil fuel is the primary source of power for most of the United States' electric generation. As a result, many of the systems in place for one power source do not work for the other, and vice versa. The short-term and spot power purchasing that is currently in place in the deregulated New York State electricity generation business is one such system that was designed for fossil-fuel-generated electricity that does not work well for wind-generated electricity.

Wind energy technology is highly capital-intensive compared with fossil fuel plants. A wind energy project requires all of its capital expenditure up front and has no fuel costs associated with its useful life (typically 20 to 25 years). Fossil fuel plants require substantially less capital for construction, typically only one-quarter to one-half the capital cost of a similarly sized wind project (depending on scale and technology employed). However, as recent experience shows, fossil fuel plants have high fuel costs that can fluctuate substantially.

The cost of wind energy is affected by average wind speed and the long-term interest rate on the capital cost of construction, as opposed to the ever-changing market price of fuel. While a wind farm's output may see drastic fluctuations from day to day, it will produce electricity at relatively constant output and cost on an annual basis. Thus, wind energy involves a predictable, longer-term debt load as well as a much smaller operations and maintenance (O&M) cost.

Financing wind projects depends on several items, including the cost of capital construction, O&M costs (which are relatively minor), and the sale price of the electricity. Given its mature technology, wind energy development is no longer considered a risky venture. Wind energy produces electricity at a fixed price over its lifetime. The sale price of wind-generated electricity over its lifetime is much more difficult to estimate with the deregulated nature of electricity generation in New York State, which was designed for fossil-fuel-generated electricity. In addition, as a result of the Enron bankruptcy, most firms no longer trade in long-term energy futures. These factors make it difficult to establish price assumptions on the sale of electricity and present challenges to wind energy projects at the time of financing.

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5 http://www.nrel.gov/wind_meetings/fy05_meeting/pdf/smith_fy2005.pdf

Wind energy offers energy security to New York State and its electricity consumers. Energy security is provided by wind energy in several ways:

- Security in price. Wind energy generates electricity at close to a fixed price over its lifetime of 20 to 25 years; it is not subject to changes in the price of fuel.
- Security in source of generation. Wind energy generated in New York is not subject to actions in other nations. With more than 65% of the world's oil located in the Middle East, and as a net importer of energy, source security is important to New York State.

Long-term PPAs are one way to ensure the financial viability and feasibility of a permitted wind energy project. Conversely, without a long-term PPA, there is considerable risk: projects are more difficult to finance, the price of power will increase, and the reliance on fossil fuels will continue. The RPS in New York State, as currently adopted, partially reduces this risk by providing long-term PPAs. This will benefit both development and New York State electric ratepayers.

ECONOMIC DEVELOPMENT AND THE RENEWABLE PORTFOLIO STANDARD

State policy is one means of ensuring that the public benefits of wind and other renewable energy are realized. New York State's RPS is a flexible, market-driven policy that establishes a standard for the amount of renewable energy included in the state's portfolio of electricity resources. As a long-term commitment by the state, the RPS sets the stage for the development of a wind industry.

Rules to implement the RPS were completed by the New York Public Service Commission in September 2004.[6] The RPS will stimulate economic development in New York State through local energy industry jobs associated with construction, operation, and maintenance and with component manufacturing. A summary of the New York State RPS is presented in Appendix H.

In general, owners of wind-energy projects can expect a new revenue source for the output produced by wind generators. The amount of revenue will be based on a competitive procurement system to be run by NYSERDA. It is difficult at this time to estimate the likely price to be paid for renewable energy under this system.

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[6] The Commission's rules were finalized on September 22, 2004. The Order can be found on the Commission Web site at: http://www3.dps.state.ny.us/pscweb/WebFileRoom.nsf/Web/85D8CCC6A42DB86F85256F1900533518/$File/301.03e0188.RPS.pdf?OpenElement.

In addition to having a strong wind resource as identified through this study, Erie County offers other benefits to the wind energy industry. The county has steel production facilities, a skilled manufacturing workforce, and a reasonable cost of labor. Its location allows large wind turbine assemblies and tower components to be transported throughout the Great Lakes and the Northeast via ship, rail, and truck. In addition, Erie County has a firm commitment to wind energy development, as demonstrated by recent meetings with major companies such as GE, Vestas, and Gamesa.

The long-term commitment by New York State to renewable energy through the RPS is important to the prospect of attracting wind turbine or component manufacturing to Erie County. Turbine sales, driven by wind energy development, enable the wind energy industry to justify the establishment of manufacturing locations. The manufacturing of wind turbines, components for turbines, or towers all would create jobs that could be located in Erie County. Some components of wind-energy systems are already manufactured in New York State (e.g., electric cable).[7]

If such manufacturing occurred in Erie County, New York State's RPS would benefit the State in terms of both jobs and long-term, pollution-free renewable energy. In bidding for wind energy contracts under the RPS, a slight preference for New York State content would encourage manufacturers to locate in New York State. Economic incentives from Erie County could further create a favorable business climate.

The RPS has tremendous value to the development of wind power in New York State. There is concern, however, that much of the value of the RPS as a development incentive could be lost if the New York State Assembly exercised an annual budget veto over RPS payments. This would put into question the ability to secure financing based on RPS contracts, increase the risk to developers, and ultimately increase the price of power to New York State ratepayers.

In addition to the RPS, limited funding is available from NYSERDA for small wind development projects. Developers should consult with NYSERDA on eligibility for funds managed through its Energy Smart program, which is funded by public benefits charges on sales of electric power. At least a portion of this program will become part of the RPS by 2006, although it is expected to operate in a fashion similar to the present program.

POTENTIAL OWNERSHIP SCENARIOS

The RPS was not in place when the Shoreline Wind Study was initiated, and there was considerable speculation about which development scenarios would work best. This has since changed as a result of the adoption of final RPS regulations by the New York State Public Service Commission.

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[7] The full report is available at http://www.repp.org.articles.static/1/binaries/WindLocator.pdf

Both public and private ownership scenarios were considered at the beginning of the study. The PTC clearly favors private development as the most viable economic scenario because tax benefits are not provided for publicly owned projects. If wind energy development were to be located on publicly owned land such as the NFTA or SSTF sites, tax benefits could be realized only through private ownership of turbines and signed land leases. While there is a mechanism for publicly owned wind development projects to receive federal funding, the availability of those funds is subject to annual appropriations and is difficult to rely upon in project development.[8]

While this study shows that the Erie County shoreline has significant wind energy resources, it does not guarantee successful development of a wind energy project. Factors such as land availability and potential on-site electric demand also determine a project's viability. Table 8 identifies some of the other factors that need to be considered in developing a wind energy project. The development potential of each site is summarized below in greater detail.

Table 8. Factors in the Successful Development of the Erie County Shoreline Wind Study Sites

Site	On-site Use of Power Possible	Potential Sale of Wind-generated Electricity to Grid	Wind Speed Potential for Utility-scale Wind Farm Development (7 m/s or greater wind speed)
GM	X		
NFTA	X	X	X
CSX	X		
ISG	X	X	X
SSTF	X	Potential*	X

* Depends on relocation of Mercy Flight operations and on-site power needs.

All of the sites studied have existing or potential on-site uses for the electricity they would generate. The economics for on-site generation are such that wind energy is viable for behind-the-meter applications at all of these sites, although it is possible that, in some circumstances, the wind power host may incur "stand-by" or "exit" fees that are applicable to on-site generation. These fees would likely be subject to size and utility, and have the potential to make a project uneconomical. The RPS as currently adopted contains provisions to encourage small on-site wind systems of 300 KW or less through the use of buy-down funds provided by NYSERDA. The industrial area of the Erie County shoreline probably was not considered in

8 http://www.awea/org/news/

this determination. Accommodating slightly larger projects within customer-sited RPS responsibility would be beneficial to wind-power development along the Erie County shoreline.

LOCAL MECHANISMS FOR PURCHASING WIND ENERGY

"Green power" costs a little more than conventional electricity, ranging from less than 1 cent to 2.5 cents per kilowatt hour extra, depending on the product and company supplying the energy (Wind Action Group)[9]. Several sources of green power are available in the region: private sources such as Community Energy, Green Mountain Energy, and Sterling Planet; and two non-profit organizations, the Energy Cooperative of New York and the New York Public Interest Research Group (NYPIRG).

These sources sell different "green power" products at various prices via Niagara Mohawk and the New York State Electric and Gas Co. (NYSEG), the two electricity suppliers serving the Western New York region. NYPIRG sells electricity produced solely by wind energy. Community Energy of New York also sells electricity that is produced solely by wind energy, as well as electricity that is produced by a combination of wind and water power. Green Mountain Energy also sells wind/water-produced electricity. Sterling Planet uses wind energy, water energy, and biomass/landfill gas to produce electricity. The Energy Cooperative of New York sells electricity generated by landfill gas and wind energy. Some industrial energy consumers in the Niagara Frontier region (including GM) have made informal commitments to purchase renewable energy through a collaborative process managed by the World Resources Institute.[10]

AVIAN ISSUES

A number of positive impacts on birds and bird populations would result from an increased use of renewable energy sources, including wind. Air emissions and global climate change have been cited as serious concerns for North American bird populations (see A Birdwatcher's Guide to Global Warming by the National Wildlife Federation and American Bird Conservancy [Price and Glick 2004]). Increased renewable energy use would slow down the negative impacts of global climate change and air emissions on people and wildlife. Wind energy facilities also have the potential to cause injury or death to birds through collisions and result in habitat loss, degradation, or displacement. While some studies have shown that these negative impacts have occurred, the results from numerous studies and reviews of avian impacts from wind energy facilities in North America and Europe indicate that avian fatality rates are low (Erickson 2001; NWCC 2004).

In November 2004, the National Wind Coordinating Committee (NWCC), a consortium of wind energy developers, researchers, proponents, opponents, and agencies, issued the second edition of a fact sheet entitled "Wind Turbine Interactions with Birds and Bats: A Summary of Research Results and Remaining

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[9] http://www.greengold.org/wind/buygreen.php

Questions" (NWCC 2004). The following, taken from the fact sheet, is part of an overview on the status of bird issues at wind energy facilities that aptly describes current understanding of the issue:

> Wind energy's ability to generate electricity without many of the environmental impacts associated with other energy sources (e.g., air pollution, water pollution, mercury emissions, and greenhouse gas emissions associated with global climate change) can significantly benefit birds, bats, and many other plant and animal species. However, the direct and indirect local and cumulative impacts of wind plants on birds and bats continue to be an issue (NWCC 2004).

Avian issues are typically a significant concern when siting a wind farm, and proposed projects face considerable scrutiny on this topic. It should be expected that the public, non-governmental organizations, and agencies will express concerns over avian issues, and that there will be some individuals and groups opposed to a proposed wind project over avian concerns regardless of the merits of the project, studies, or site. On a regional and local level, several area birding and/or conservation groups, including the Buffalo Ornithological Society and Buffalo Audubon Society, would likely be interested in learning the details of any proposed wind projects along the Erie County shoreline.

NYSDEC and the USFWS are typically either involved agencies or interested parties under the SEQR permitting process. Both agencies recommend that the developer consult with them regarding proposed projects and that they be involved with the scoping of avian studies. NYSDEC typically recommends a variety of avian studies, including nocturnal radar studies (spring and fall migration seasons), raptor migration studies, and breeding bird surveys, be conducted at each proposed site. The USFWS is in the process of developing a set of comprehensive national guidelines for siting and constructing wind energy facilities, and in May 2003 it issued draft interim siting guidelines to avoid or minimize impacts on wildlife associated with wind turbines (see http://www.fws.gov/r9dhcbfa/windenergy.htm).

The urban and industrial settings of the Shoreline Study sites provide poor-quality habitat for most bird species. Because of the poor habitat, a relatively low number and diversity of birds would be expected at the actual site locations. However, there are several areas relatively close to the five wind study sites that are well known for bird habitat and abundance. These areas are described below and identified by site in Table 9. A more detailed description of data related to the five sites is provided in Appendix G.

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[10] See http://climate.wri.org/newsrelease_text.cfm?NewsReleaseID=313 and www.thegreenpowergroup.org

Table 9. Bird Habitat and Abundance Sites Near Shoreline Wind Study Sites

Site	Location of Nearest Bird Habitat(s)
GM	Niagara River, Motor Island/Strawberry Island
NFTA	Times Beach Nature Preserve, Tifft Nature Preserve
CSX	South of Tifft Nature Preserve
ISG	South of Tifft Nature Preserve, Lake Erie
SSTF	Woodlawn Beach State Park, Lake Erie

Two of the areas identified in Table 9, the Niagara River and Tifft Nature Preserve, have been classified by Audubon New York as Important Bird Areas (IBAs) (Burger and Liner 2005). IBAs are recognized by Audubon New York for providing essential habitat to birds. Several criteria are used for identifying IBAs, but sites are designated as IBAs generally based on the presence of threatened/endangered species or large concentrations of birds during the breeding, migratory, and/or winter seasons. The IBA designation does not offer any additional legal protection or limitations; however, it is a clear identification of an area with conservation concerns. Beyond the Audubon New York list, the Niagara River IBA is a globally recognized IBA and is included as one of the top 500 IBAs in the United States by the American Bird Conservancy (American Bird Conservancy 2003). The Niagara River Corridor IBA is recognized primarily for its stopover and wintering habitat for large concentrations of waterfowl and gulls. There is considerable waterfowl use and migration on the Niagara River and Lake Erie; however, this use is primarily limited to the actual water bodies and does not significantly involve the adjacent land. The breakwalls and structures on the Buffalo waterfront also provide excellent breeding habitat for colonial nesting waterbirds, including Ring-billed Gulls, Common Terns, and Double-crested Cormorants. The Tifft Nature Preserve is recognized as an important stopover site during migrations and for its high diversity of bird species (over 260 recorded at the site), including some threatened and endangered species.

While not categorized as IBAs, several other important bird areas are located near the five wind study sites. Times Beach Nature Preserve and Woodlawn Beach State Park are well known as popular birding areas. More than 230 and 160 species have been documented at these locations, respectively. Public funding has been used to improve access and habitat at both of these areas in recent years.

The breakwalls on the Buffalo waterfront and islands on the Niagara River provide excellent breeding habitat for colonial nesting waterbirds (e.g., gulls, terns, herons, cormorants). The proximity of these colonies will likely be a consideration during avian review of several of these study sites. The mouth of Lake Erie and the upper Niagara River also provide seasonal habitat for thousands of migratory and wintering waterfowl and gulls from October through April. However, this use is primarily limited to the actual water bodies and not the adjacent land.

Because of their proximity to Lake Erie, the study sites are within a regional area (i.e., all property within several miles of Great Lakes shorelines) considered to be an increased migratory pathway. While the industrial settings and poor habitats at the study sites do not attract migrating birds or provide stopover habitat, there is a probability that increased numbers of songbirds and other species migrate over the study sites at night.

Migrating, raptors avoid flying directly over large bodies of water whenever possible. Their migration flight is aided by thermals that help them conserve energy, and these thermals do not occur over the cold waters of large lakes. As raptors fly north in spring, they encounter the shore of Lake Erie and turn to the northeast to fly parallel to the shoreline. Thus, Lake Erie's southern shore concentrates the raptors along the shore until they reach the terminus of Lake Erie, near the study sites. The raptors then either turn to the west into Canada or fly east along the southern shore of Lake Ontario. Therefore, raptors concentrate along the southern shores of the Great Lakes during the spring migration and along the northern shores of the Great Lakes during the fall migration. The Hamburg Hawk Watch monitoring site, located on Camp Road in the town of Hamburg, just southeast of the SSTF Site, is the closest raptor monitoring location. During the spring 2005 migration, over 13,000 raptors were tallied by the Hamburg Hawk Watch, which provided daily coverage from March 1 to May 15.

ENVIRONMENTAL PERMITTING AND RISK

Before developing a wind resource, a developer must procure land leases to monitor the wind; obtain federal, state, and local permits and approvals; and secure equity investors and bank financing. While a certain level of uncertainty is associated with financing a wind project, the steps prior to obtaining funding are considered the riskiest.

The regulatory process comprises a significant portion of the pre-construction effort. Over the last several years, approval and development of wind-energy projects throughout New York State have involved various environmental issues, time frames, and costs. Ultimately, the lower or higher cost of wind-generated electricity can be associated with the ease of the regulatory process. To the extent that permit-related risks can be minimized, the price of generating electricity from wind energy can also be reduced.

The regulatory process involves federal, state, and local permitting and approvals. Federal and local permitting issues were discussed in Section 3. The SEQR process, another important consideration in developing a wind farm, is described below.

All state, county, and local/municipal agencies must comply with SEQR. The process is triggered whenever a state agency directly undertakes, funds, or approves an action. Key issues typically relevant to wind projects are avian impacts, cultural resources, visual impacts, biological considerations, and noise. Typically, wind project proposals necessitate the establishment of a lead agency (usually the local municipality) to oversee the SEQR process and classify the proposed action according to SEQR criteria. The Project Applicant must file a SEQR Long EAF describing the proposed project with the lead agency. The local governing authority, the public, and other stakeholders largely determine the scope and level of further analysis. If stakeholders are unfamiliar with the specifics of the proposed project, or if they anticipate significant adverse impacts or public controversy, a more detailed level of analysis may be requested, requiring the preparation of an environmental impact statement (EIS). An EIS requires a more thorough evaluation of impacts, associated studies, and a longer time frame for preparation, review, and approval. A wind-energy developer can reduce the likelihood of having to prepare an EIS and minimize overall risk by fostering community education and acceptance well in advance of the SEQR process; siting turbines on properties having no or few environmental constraints; and being knowledgeable about state policy and local permitting issues.

BROWNFIELD RECLAMATION OPPORTUNITY

Development of wind farms can provide opportunities to reclaim brownfield sites, bringing them back into beneficial use (American Wind Energy Association [AWEA][11]). In early 2003, ISG purchased the former Bethlehem Steel property, which covers 1,300 acres of fallow shorefront real estate. The property is an ideal location for many new industries because of its efficient transportation network, logistical infrastructure, and regional access to a highly educated and trained workforce. As the cost of energy is important to any new industrial plant, this site could be well-suited for future development. A wind farm would occupy only a small fraction of the ISG property, allowing the remaining land to be developed in such a way as to attract more industry and jobs to Erie County and Western New York.

The issues typically associated with wind farms would be less significant on the ISG property than on other, more rural sites. These issues include new visual impacts on surrounding, undeveloped land; access for construction vehicles; and removal of valuable land cover, among others.

- A series of wind turbines would be consistent with or potentially improve the current viewshed; and could change the site's industrial image to a more environmentally friendly one.
- The ISG site contains access roads and cleared areas that could be used for construction vehicles.
- As a brownfield site, it does not have otherwise valuable land cover. The property is currently contaminated with process waste from Bethlehem Steel operations and is listed as a Class 2 site on the New York State Registry of Inactive Hazardous Waste

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11 American Wind Energy Association. March 10, 2004. *Global Wind Power Growth Continues to Strengthen*. http://www.awea.org/news/news040310glo.html

Disposal Sites. A Resource Conservation and Recovery Act (RCRA) facility investigation is nearing completion, and remedial concepts are being developed. As the area is subdivided and “clean” areas developed, opportunities will arise for a more diverse range of industries to locate on this site.

The ISG site does present some issues. As indicated by its very nature as a brownfield site, the ground upon which the wind turbines would be sited has been reclaimed using steel slag and other materials. This presents challenges for ensuring that the foundations are sufficient for safe and cost-effective construction and operation. Even many years after being deposited at a site, steel slag may expand and cause difficulties with foundations. A siting assessment could better evaluate the development of the property as an urban energy generation facility.

Another consideration with this site is current ownership. The Benchmark Group, which managed the site locally, was amenable to exploring the potential for developing wind-energy projects and worked with the county to install a monitoring tower on the site, as originally planned with Bethlehem Steel. However, the ISG site again changed ownership in 2004 when a privately owned Dutch steelmaker purchased the parcel. The new owners would benefit from updates in the local regulatory structure and the compatibility of wind power development with ongoing industrial operations and uses proposed on adjacent properties.

Section 7
CONCLUSIONS

New York State has taken a major step toward encouraging wind energy development with the adoption of the RPS, which will improve the state's energy security and reduce dependence on non-renewable energy sources. Economic incentives such as the federal PTC, potential long-term PPAs, and brownfield tax credits will further promote the development of wind energy in New York State, providing a stable energy supply to consumers.

Development of an urban wind farm in Western New York could serve to elevate the region's image while creating economic opportunities for its residents. As demonstrated by this study, the New York State Wind Resource Map is a useful and reliable tool for determining which locations may have development potential.

GM SITE

Monitoring at the GM site validated the predicted wind resource near the northern end of the Erie County shoreline. Although the GM site has the lowest wind resource of the five monitored sites, it is still a reasonable candidate for a wind power project.

The GM property occupies 160 acres in the G-I zoning district of the Town of Tonawanda. The site is bounded by American Axle Manufacturing, Inc., Niagara Mohawk, and other privately held G-I properties. The land use code is industrial—specifically, manufacturing and processing.

The only development activity planned in the near future involves demolition of at least one building on the property. Barriers to developing a wind energy project include the current site uses—commercial office buildings and surface parking lots bordered by the NYS I-190—that could limit the number of possible turbines that could be constructed. The clean fill area, located on the northern portion of the site, is currently unused.

The Town of Tonawanda required a special use permit for construction of a meteorological tower on this site. A similar process would likely be followed for construction of one or more wind turbines. Construction of a turbine on the GM site represents a "green manufacturing" opportunity for GM and would likely result in positive visual effects on the industrial property.

The GM site also offers access to existing electrical transmission lines. GM owns a substation and uses electrical power on its properties. In addition, the company is currently experiencing voltage drops below 115 VAC, which on-site wind turbines could help alleviate.

NFTA SITE

Situated on a publicly owned parcel west of Fuhrmann Boulevard in the City of Buffalo, the tower on the NFTA site was able to provide wind measurement data at a height of approximately 100 meters. The site is a good wind energy resource, as indicated by the monitoring results. The site would be a good candidate for a utility-scale wind farm in terms of available acreage (more than 100 acres). The site is classified as commercial and is approved for the use of piers, wharves, docks, and related facilities. It is zoned M-2, or General-Industrial. Surrounding uses are primarily vacant, commercial, or industrial, and include other NFTA-owned property, Freezer Queen Foods, Inc., and the Conrail-Buffalo Creek Rail right-of-way.

Currently, the land at this site is unoccupied and is undergoing hazardous waste remediation activities required by NYSDEC. An additional 105 acres of NFTA-owned property are located north of the site. While future development scenarios have not yet been identified for this parcel, the site represents a wide variety of opportunities and presents no significant land use, zoning, or development constraints.

CSX SITE (Southern Portion)

The CSX site (southern portion) presents a “green” industrial opportunity on a site slightly inland from the shoreline. The CSX site is situated on approximately 16 acres of vacant land, south of Tifft Street and just north of the CSX railroad yard in the City of Buffalo. The data showed that the CSX site is a good wind resource, and because the site is relatively flat, cleared, and undeveloped, several wind turbines could be accommodated.

The parcel is located in the C-1 zoning district (Neighborhood Business District) and is within the City of Buffalo Special Coastal Overlay District because it is within 1 mile of Lake Erie. Permitting issues may arise due to its special zoning designation, as demonstrated by the requirement to obtain a restricted use permit for construction of the Shoreline Study meteorological tower. Other constraints include hard soil and industrial landfill, which may complicate turbine installation.

ISG SITE

As indicated by the data, the ISG site is the best of the locations studied during the 12-month monitoring period. The site is a good candidate for a utility-scale wind farm because of its wind resource characteristics, brownfield redevelopment potential, easy access for tower and turbine installation, and ability to connect to the existing electrical grid. A series of wind turbines would not visually detract from the current viewsheds on this industrial site and could markedly improve the site’s image.

The ISG property is an ideal location for many new industries due to its efficient transportation network and logistical infrastructure. As the cost of energy is important to any new industrial plant, this site would be well suited to future development. Various active and/or passive recreational activities intended to revitalize the waterfront area have been proposed for portions of the ISG site. A wind farm would occupy only a small fraction of the ISG land, allowing the remaining land to be developed in such a way as to attract more industry and jobs to Erie County and Western New York.

The property is currently contaminated with process waste from Bethlehem Steel operations and is listed as a Class 2 site on the New York State Registry of Inactive Hazardous Waste Disposal Sites. A RCRA facility investigation is nearing completion, and remedial concepts are being developed. However, as the area is subdivided and "clean" areas developed, opportunities will arise for a more diverse range of industries to locate on the site.

The ISG site does present some issues due to its nature as a brownfield. The ground upon which the wind turbines would be sited has been reclaimed using steel slag and other materials. This presents challenges for ensuring that the foundations are sufficient for safe and cost-effective construction and operation. Even many year after being deposited at a site, steel slag may expand and cause difficulties with foundations. A siting assessment could better evaluate the development of the property as an urban generation facility.

Another consideration is the recent change in ownership. The new owners would benefit from updates in the local regulatory structure and the compatibility of wind-power development with ongoing industrial operations and uses proposed for adjacent properties.

SSTF SITE

The county-owned SSTF site showed good extrapolated wind data. The 43-acre property is located along Lake Erie, west of Lakeshore Boulevard. The site is zoned M-2 (General-Industrial) and is classified as a public service use. The site contains a county-owned and operated sewage treatment plant. The Ford Motor Company Stamping Plant is located approximately 150 meters to the east, and the Lake Erie shoreline is approximately 400 meters to the west. The SSTF parcel is surrounded by single-story, light industrial facilities at a minimum distance of several hundred meters away.

The property was initially a solid candidate for wind monitoring and potential turbine development, but it also presented significant flaws related to existing operations. Due to aviation concerns associated with Mercy Flight, a regional medical emergency transport service, sodar equipment was used to monitor the wind resource at this site. While the site currently presents constraints with regard to FAA requirements, Mercy Flight is being evaluated for relocation. If Mercy Flight operations are relocated, the parcel could present development opportunities, given its easy access to the electric grid and the potential for on-site use of electricity.

Section 8
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APPENDIX A

SITE SUMMARIES

Basemap Source: Reverse-Color Infrared USGS DOQQs, 1995-1998

Figure A-1
MET Tower Monitoring Locations

GM SITE

GENERAL MOTORS (GM) SITE (CLEAN FILL AREA)

Although the GM location has the lowest wind resource of the five monitored sites, it is still a good candidate for wind power. GM has a need for power on its properties, owns a substation, has good power connectivity, and would view the installation of wind turbines as a positive, “green” message to its customers. GM has also been experiencing equipment problems related to voltage drops below 115 VAC that on-site wind turbines could help alleviate. No new on-site development is planned for the future, with the exception of the demolition of at least one building on the property.

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001584.NE05.01
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FIGURE A-3
GM POWERTRAIN
TOWER LOCATION
WITH ZONING

NFTA SITE

NIAGARA FRONTIER TRANSPORTATION AUTHORITY

The NFTA has a good wind resource, as indicated by the monitoring results. The site would be a good candidate for a utility-scale wind farm in terms of available acreage (100 acres) once remediation activities required by the New York State Department of Environmental Conservation (NYSDEC) are completed.

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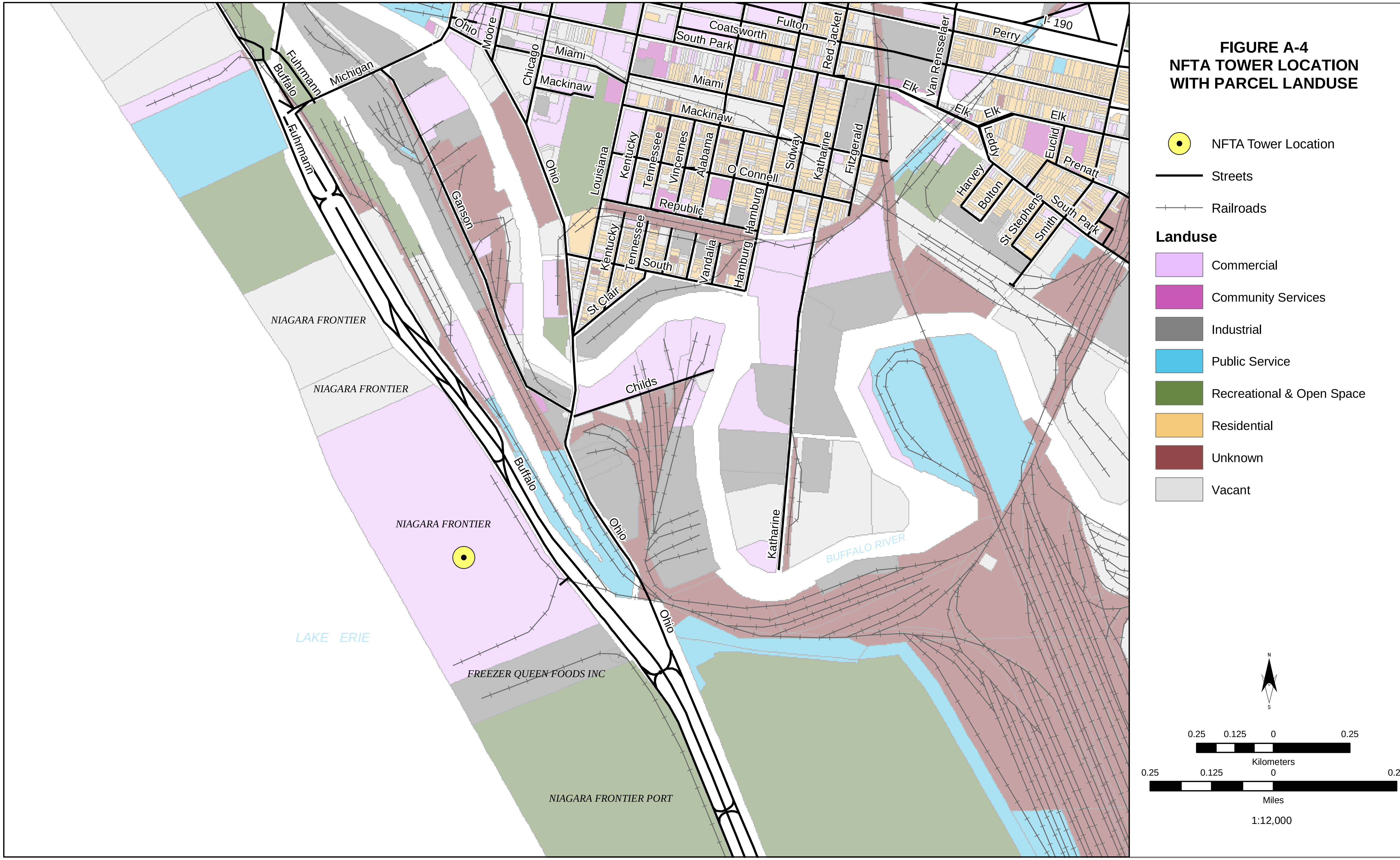
FIGURE A-4
NFTA TOWER LOCATION WITH PARCEL LANDUSE



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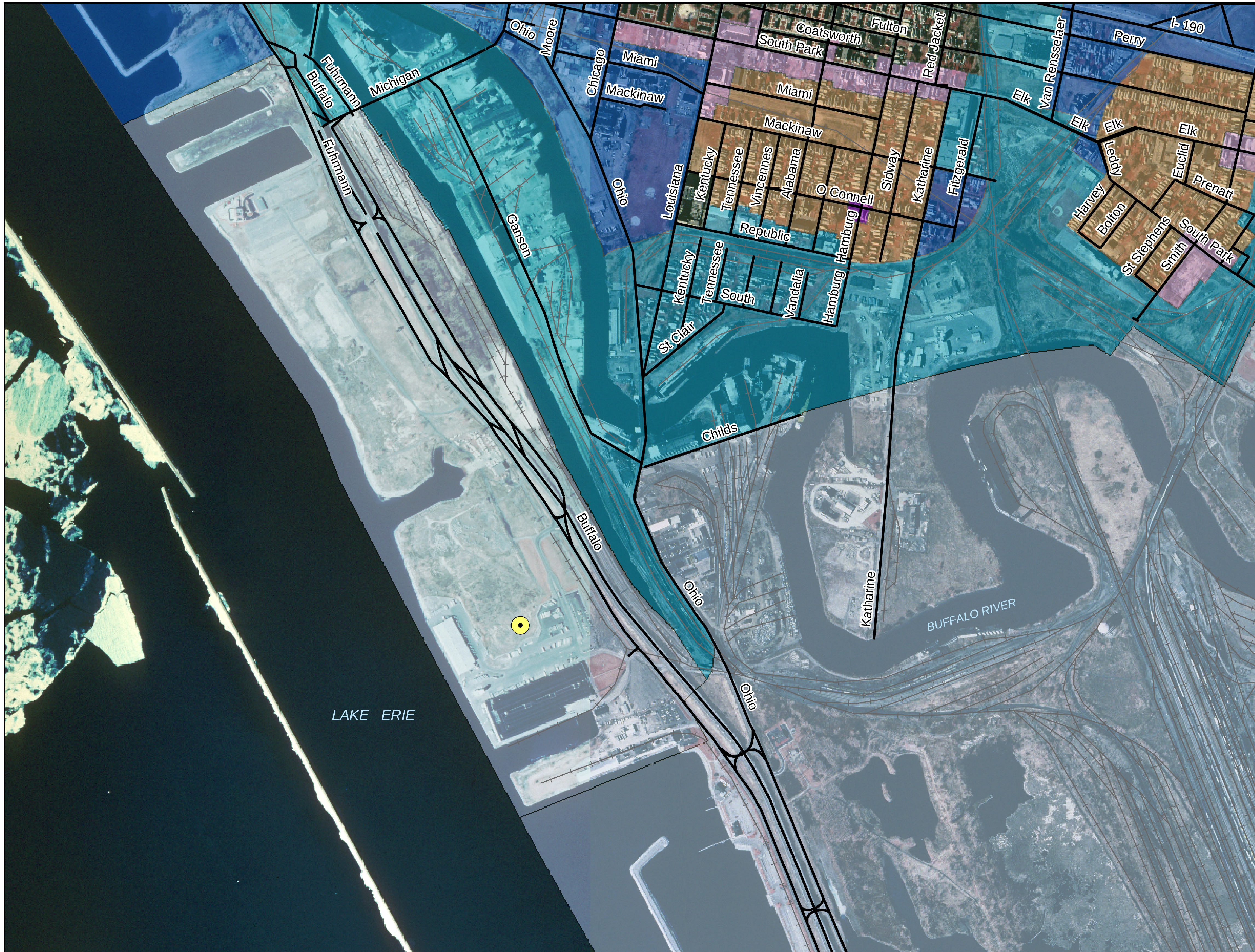
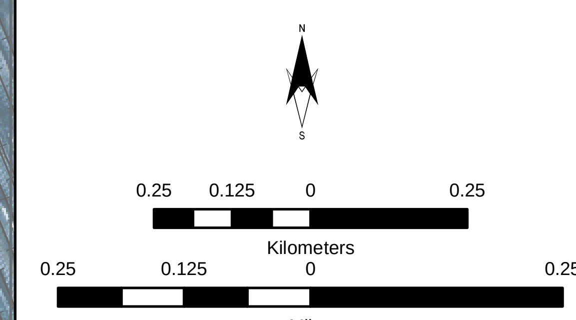


FIGURE A-5
NFTA TOWER LOCATION WITH ZONING

NFTA Tower Location
Streets
Railroads

ZONING

Neighborhood Business
Community Business
Light Industrial
General Industrial
Heavy Industrial
Dwelling District



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CSX SITE

CSX (SOUTHERN PORTIONS)

The CSX site also is a good wind resource. The parcel is 16 acres of vacant land, which presents a development opportunity with few obstructions. Permitting issues may arise due to its location in a Special Coastal Overlay District in the City of Buffalo. In addition, hard soil and industrial landfill may complicate the installation of a wind turbine. However, the site represents an opportunity as greening industrial, which may encourage development on nearby industrially zoned parcels.

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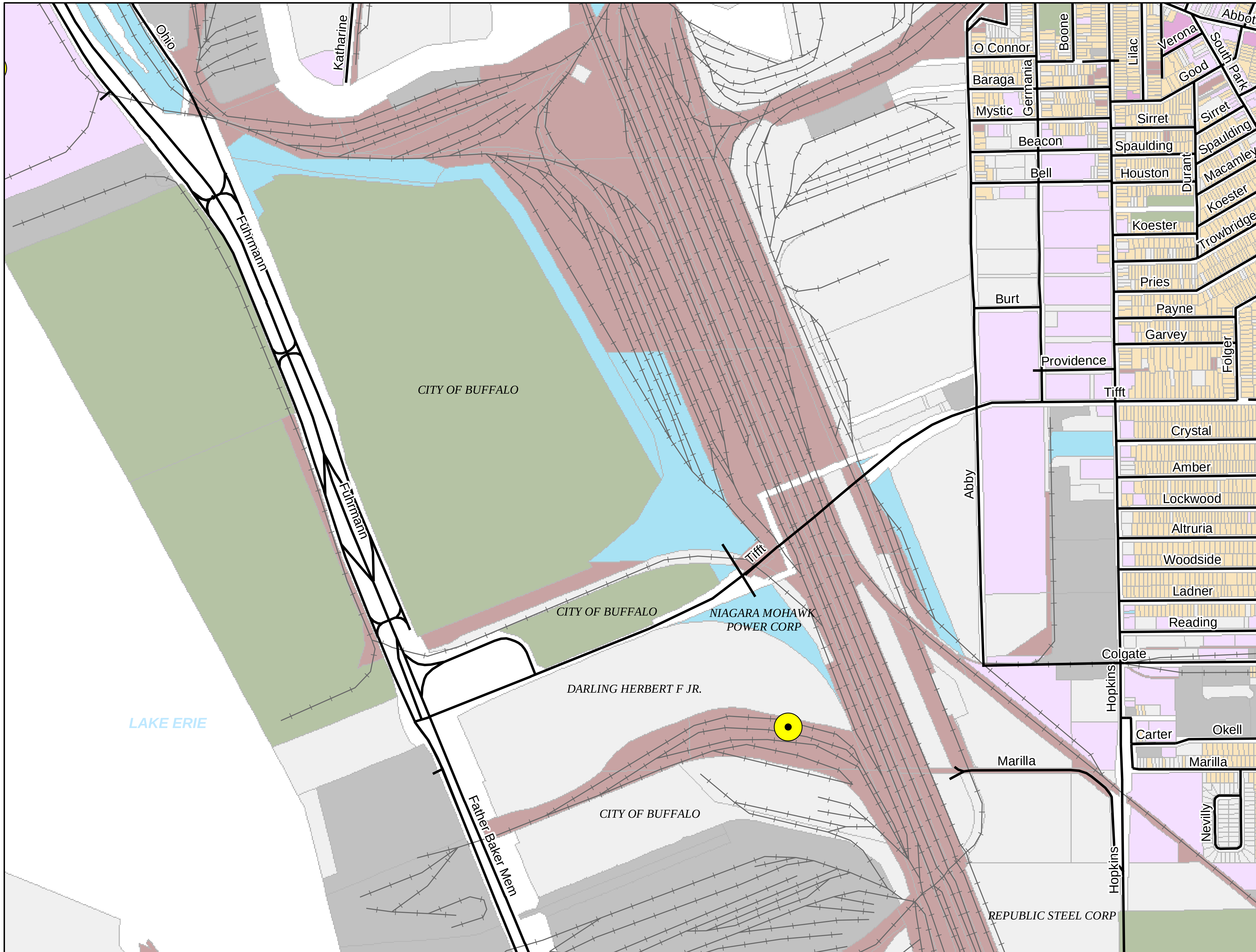

FIGURE A-6
CSX TOWER LOCATION WITH PARCEL LANDUSE

CSX Tower Location
Streets
Railroads

Landuse

Commercial
Community Services
Industrial
Public Service
Recreational & Open Space
Residential
Unknown
Vacant
OWNER Parcel Owner

N
S

0.25 0.125 0 0.25
Kilometers
0.25 0.125 0 0.25
Miles
1:12,000

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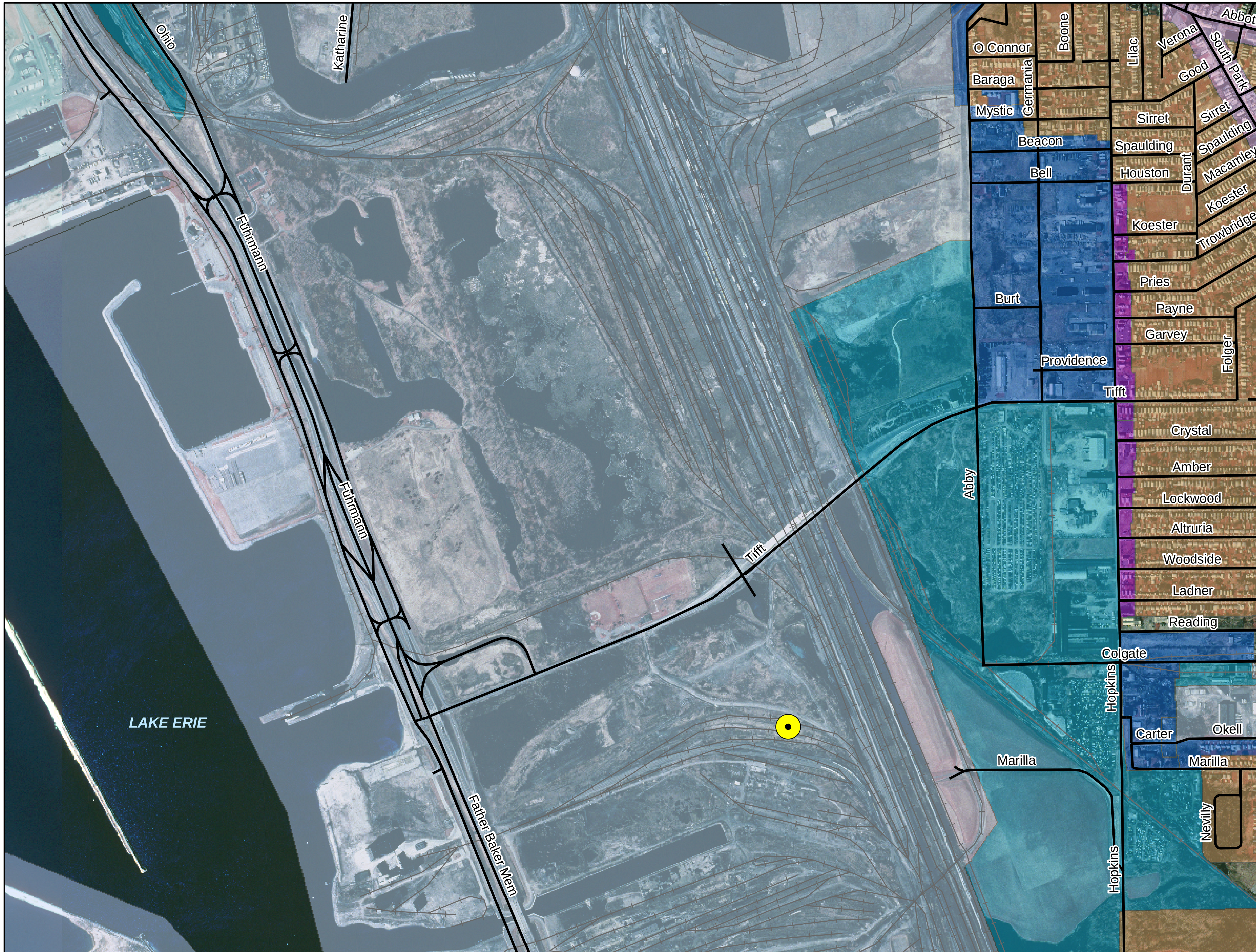

FIGURE A-7
CSX TOWER LOCATION WITH ZONING

CSX Tower Location

Streets

Railroads

ZONING

Neighborhood Business

Community Business

Light Industrial

General Industrial

Heavy Industrial

Dwelling District

0.25 0.125 0 0.25
Kilometers

0.25 0.125 0 0.25
Miles

1:12,000

ISG SITE

INTERNATIONAL STEEL GROUP (ISG)

As indicated by the data, the ISG site has the best wind of the locations surveyed during the 12-month monitoring period. The site is a good candidate for a utility scale wind farm because of its good wind resource, brownfield redevelopment potential, easy access for tower and turbine installation, and connectivity to the power grid. The ISG site is currently being evaluated with respect to environmental/hazardous waste remediation on portions of the parcel. Other assets include large tracts of land available for subdivision and general compatibility of wind turbine development with existing and planned development activities.

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FIGURE A-8
ISG TOWER LOCATION WITH PARCEL LANDUSE

ISG Tower Location

Streets

Railroads

Landuse

- VACANT LAND
- AGRICULTURAL
- COMMERCIAL
- COMMUNITY SERVICES
- INDUSTRIAL
- PUBLIC SERVICES
- RECREATION AND ENTERTAINMENT
- RESIDENTIAL
- CONSERVATION LANDS AND PUBLIC PARKS

OWNER Parcel Owner

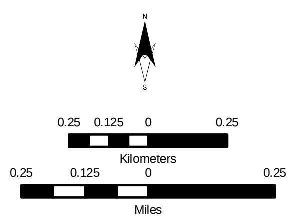

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FIGURE A-9
ISG TOWER LOCATION

ISG Tower Location
Streets
Railroads

N
S

0.25 0.125 0 0.25
Kilometers
0.25 0.125 0 0.25
Miles
1:12,000

SSTF Site

SOUTHTOWNS SEWAGE TREATMENT FACILITY

While the county-owned SSTF site was initially a solid candidate for wind monitoring and potential turbine development, it also presented significant flaws related to existing operations. Due to aviation concerns associated with the Mercy Flight heliport and landing pad, Sodar equipment had to be used to monitor the wind resource. While the extrapolated mean wind speed was good, locating wind turbines at this site would be incompatible with existing operations.

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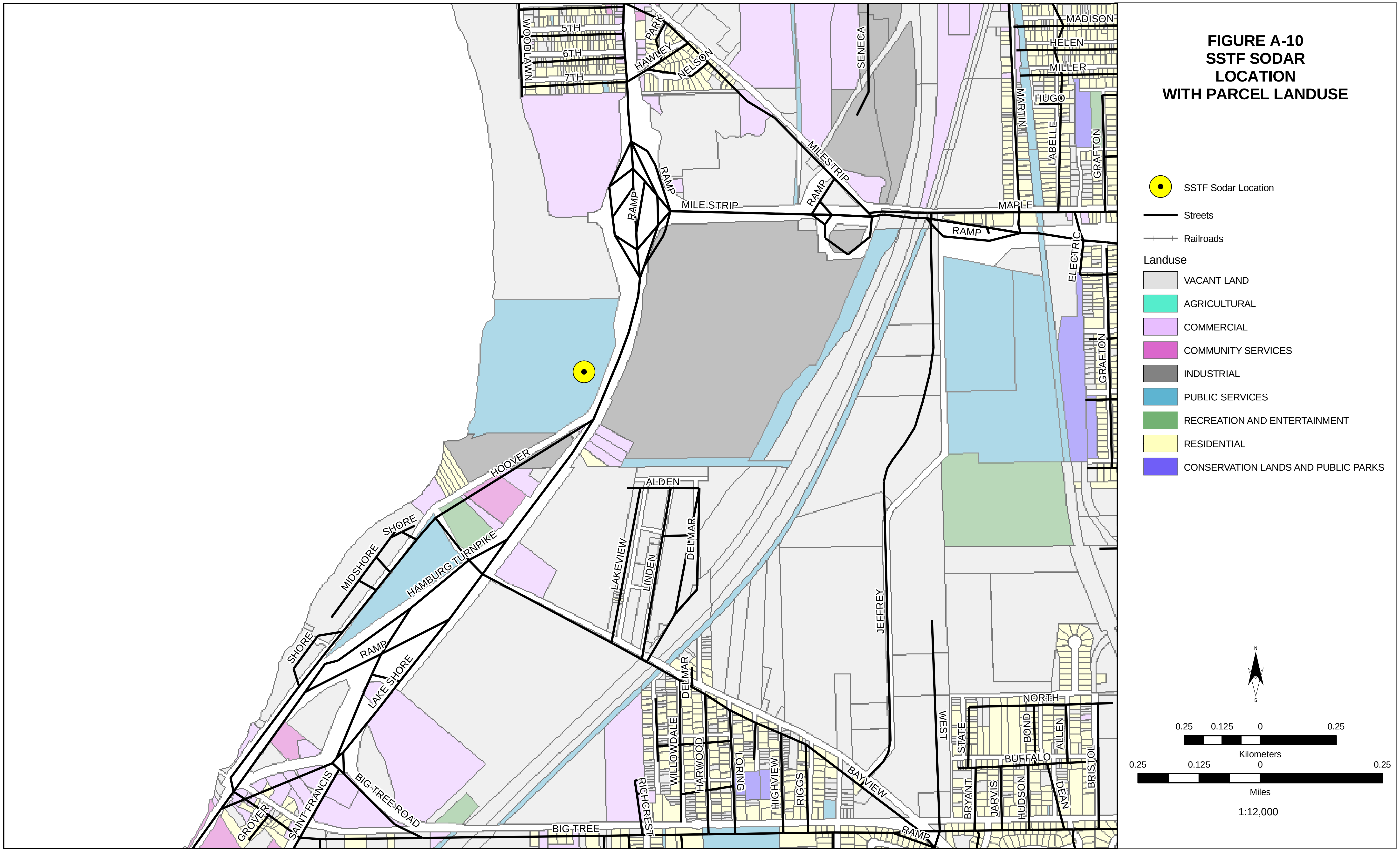
FIGURE A-10
SSTF SODAR LOCATION WITH PARCEL LANDUSE



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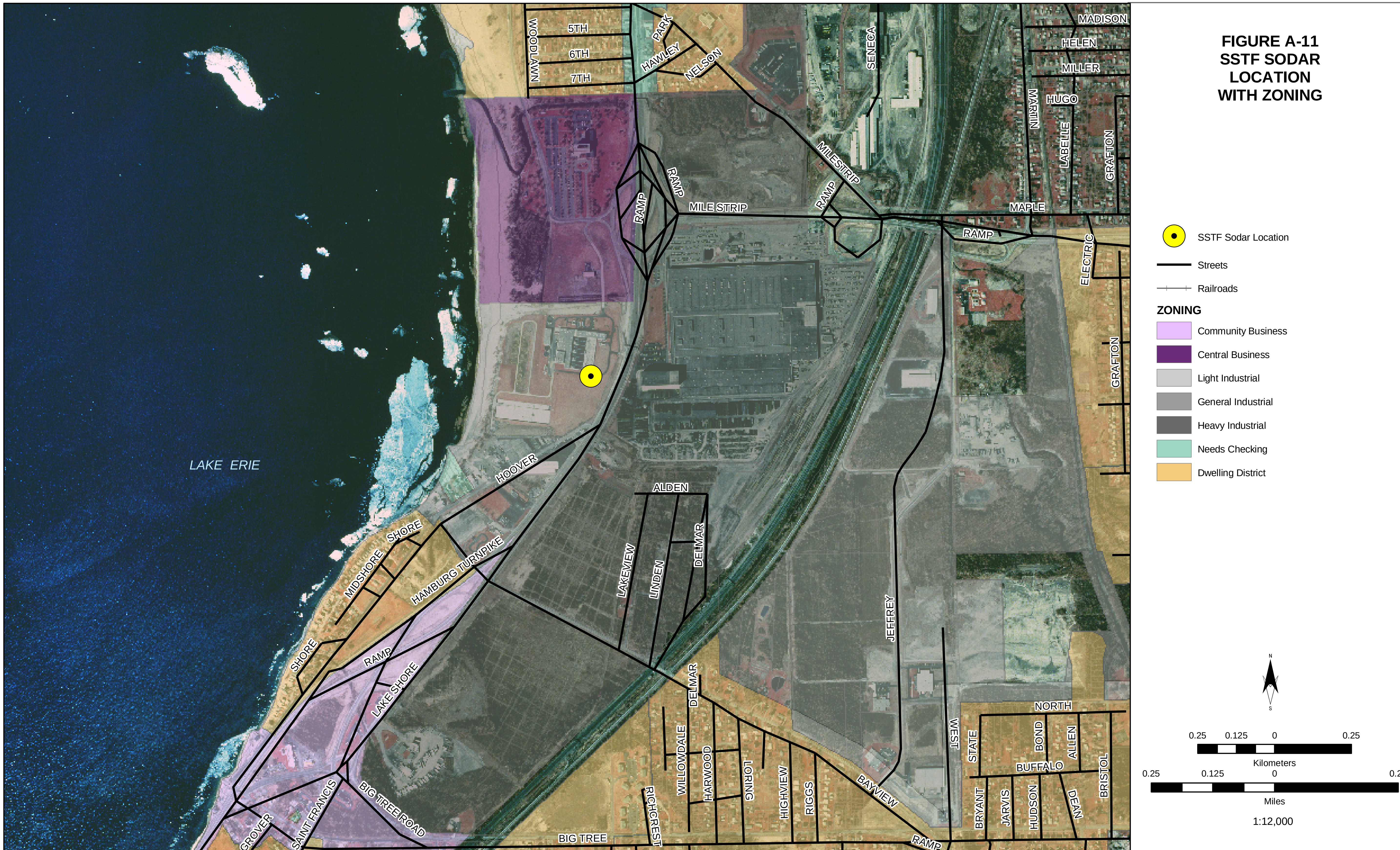

**FIGURE A-11
SSTF SODAR
LOCATION
WITH ZONING**

APPENDIX B
MONITORING SITE ENERGY PRODUCTION AND TURBINE PERFORMANCE REPORTS

Figure B1. Energy Output and Turbine Performance for NFTA

General Site Information

Site Name	NFTA Tower
Location	Eastern Shore of Lake Erie
Lat / Long (deg N / deg W)	42° 31' 23.4" / 78° 52' 19.2"
Data Period	June 2003 - May 2004
Site Elevation (m)	172

Turbine Data	**Units**						
Turbine model		**GE 1.5 / 77 m**	**GE 1.5 / 82.5 m**	**Vestas V-82**	**Gamesa G-87**	**GE 2.3 MW**	**GE 2.3 MW**
Nameplate capacity	kW	1500	1500	1650	2000	2300	2300
Hub height	m	80	80	80	80	80	100
Rotor diameter	m	77	82.5	82	87	94	94

Energy Output Data	**Units**						
Turbine model		**GE 1.5 / 77 m**	**GE 1.5 / 82.5 m**	**Vestas V-82**	**Gamesa G-87**	**GE 2.3 MW**	**GE 2.3 MW**
Average Wind Speed	m/s	7.20	7.20	7.20	7.20	7.20	7.49
Average Air Density	kg/m^3	1.22	1.22	1.22	1.22	1.22	1.22
Gross Annual Energy Production	MWh	4784	5111	5282	6301	7224	7671
Gross Capacity Factor	%	36.4%	38.9%	36.5%	36.0%	35.9%	38.1%
Percent Energy Loss	%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%
Net Annual Energy Production	MWh	4210	4498	4649	5545	6357	6751
Net Capacity Factor	%	32.0%	34.2%	32.2%	31.7%	31.6%	33.5%

AWS Truewind

Figure B2. Energy Output and Turbine Performance for GM

General Site Information

Site Name	GM Tower
Location	Eastern Shore of Lake Erie
Lat / Long (deg N / deg W)	42^{o} 58' 14.9" / 78^{o} 54' 34.0"
Data Period	September 2003 - August 2004
Site Elevation (m)	178

Turbine Data	**Units**						
Turbine model		**GE 1.5 / 77 m**	**GE 1.5 / 82.5 m**	**Vestas V-82**	**Gamesa G-87**	**GE 2.3 MW**	**GE 2.3 MW**
Nameplate capacity	kW	1500	1500	1650	2000	2300	2300
Hub height	m	80	80	80	80	80	100
Rotor diameter	m	77	82.5	82	87	94	94

Energy Output Data	**Units**						
Turbine model		**GE 1.5 / 77 m**	**GE 1.5 / 82.5 m**	**Vestas V-82**	**Gamesa G-87**	**GE 2.3 MW**	**GE 2.3 MW**
Average Wind Speed	m/s	6.11	6.11	6.11	6.11	6.11	6.45
Average Air Density	kg/m^3	1.22	1.22	1.22	1.22	1.22	1.22
Gross Annual Energy Production	MWh	3428	3796	3836	4481	5099	5715
Gross Capacity Factor	%	26.1%	28.9%	26.5%	25.6%	25.3%	28.4%
Percent Energy Loss	%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%
Net Annual Energy Production	MWh	3016	3340	3376	3944	4487	5029
Net Capacity Factor	%	23.0%	25.4%	23.4%	22.5%	22.3%	25.0%

AWS Truewind

Figure B3. Energy Output and Turbine Performance for CSX

General Site Information

Site Name	CSX Tower
Location	Eastern Shore of Lake Erie
Lat / Long (deg N / deg W)	42^{o} 50' 19.4" / 78^{o} 50' 39.4"
Data Period	September 2003 - August 2004
Site Elevation (m)	174

Turbine Data	**Units**						
Turbine model		**GE 1.5 / 77 m**	**GE 1.5 / 82.5 m**	**Vestas V-82**	**Gamesa G-87**	**GE 2.3 MW**	**GE 2.3 MW**
Nameplate capacity	kW	1500	1500	1650	2000	2300	2300
Hub height	m	80	80	80	80	80	100
Rotor diameter	m	77	82.5	82	87	94	94

Energy Output Data	**Units**						
Turbine model		**GE 1.5 / 77 m**	**GE 1.5 / 82.5 m**	**Vestas V-82**	**Gamesa G-87**	**GE 2.3 MW**	**GE 2.3 MW**
Average Wind Speed	m/s	6.41	6.41	6.41	6.41	6.41	6.72
Average Air Density	kg/m^3	1.23	1.23	1.23	1.23	1.23	1.23
Gross Annual Energy Production	MWh	3867	4220	4319	5069	5778	6289
Gross Capacity Factor	%	29.4%	32.1%	29.9%	28.9%	28.7%	31.2%
Percent Energy Loss	%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%
Net Annual Energy Production	MWh	3403	3714	3801	4461	5084	5535
Net Capacity Factor	%	25.9%	28.3%	26.3%	25.5%	25.2%	27.5%

AWS Truewind

Figure B4. Energy Output and Turbine Performance for ISG

General Site Information

Site Name	ISG Tower
Location	Eastern Shore of Lake Erie
Lat / Long (deg N / deg W)	42^o 49' 12" / 78^o 52' 6.8"
Data Period	September 2003 - August 2004
Site Elevation (m)	181

Turbine Data	**Units**						
Turbine model		**GE 1.5 / 77 m**	**GE 1.5 / 82.5 m**	**Vestas V-82**	**Gamesa G-87**	**GE 2.3 MW**	**GE 2.3 MW**
Nameplate capacity	kW	1500	1500	1650	2000	2300	2300
Hub height	m	80	80	80	80	80	100
Rotor diameter	m	77	82.5	82	87	94	94

Energy Output Data	**Units**						
Turbine model		**GE 1.5 / 77 m**	**GE 1.5 / 82.5 m**	**Vestas V-82**	**Gamesa G-87**	**GE 2.3 MW**	**GE 2.3 MW**
Average Wind Speed	m/s	7.75	7.75	7.75	7.75	7.75	8.06
Average Air Density	kg/m^3	1.23	1.23	1.23	1.23	1.23	1.23
Gross Annual Energy Production	MWh	5267	5476	5711	6969	7982	8426
Gross Capacity Factor	%	40.1%	41.7%	39.5%	39.8%	39.6%	41.8%
Percent Energy Loss	%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%
Net Annual Energy Production	MWh	4635	4819	5026	6133	7024	7415
Net Capacity Factor	%	35.3%	36.7%	34.8%	35.0%	34.9%	36.8%

APPENDIX C

PROPOSED METEOROLOGICAL TOWER SURVEY AND RECOMMENDATION

Proposed Meteorological Tower Survey & Recommendations

Ecology & Environment

Southtowns Sewage Treatment Facility

Prepared By
WIlliam D. Banas
for Ecology & Environment, Inc.
19 November 2002

Objective

The objective of this report is to analyze, on behalf of Ecology & Environment, Inc. (E&E), the possibility of placing a 165-foot-tall meteorological tower on the property of the Southtowns Sewage Treatment Facility in Blasdell (Woodlawn), NY so as to not interfere with current and future aviation-related operations at the adjacent heliport (Heussler Hamburg, OØ1). In addition to providing information to E&E to make a decision, I will provide recommendations.

Summary & Recommendations

It is possible to construct a 165-foot-tall meteorological tower on the property of the Southtowns Sewage Treatment Facility (SSTF) and avoid aviation-related operations at the adjacent heliport. To avoid aviation operations and to increase chances for FAA approval, I recommend that the tower be placed as far south as practical on the SSTF property, as far away as possible from the heliport and its approach/departure corridors. However, there is more flexibility in the placement of the meterological tower if it is built and then taken down before December 2003, when the heliport is currently scheduled to be moved and expanded (compare the shaded areas of Figures 1 and 2).

In any case, the FAA must be notified of this construction because of its height and proximity to the heliport. This notice must be submitted on the appropriate forms at least 30 days before (1) the start of construction or (2) the date an application for a construction permit is to be filed, whichever is earlier. See below for details.

The FAA will then issue a determination that the construction (1) would not be a hazard to air navigation or (2) would be a hazard to air navigation. If it is determined to be a hazard, you may request an “appeal” within 30 days for the FAA to review and reconsider their determination. In their determination, the FAA may also require supplemental notices or lighting/marking of the structure. Unless otherwise extended, revised, or terminated, an FAA determination of “no hazard” expires 18 months after its effective date, regardless of whether construction has started.

Although the FAA has no authority to approve or deny construction, their recommndations are, according to the FAA, “not easily dismissed” (usually in local court or before a zoning/planning board).

I recommend that the notification process begin at least eight weeks before the start of construction (or application for construction permits, whichever is earlier) because of FAA notification requirements and the somewhat lengthy process of completing the proper FAA forms.

Details

Background. Ecology & Envioronment, Inc. is interested in placing a 165-foot-tall meteorological tower on the property of the Southtowns Sewage Treatment Facility (SSTF). Immediately adjacent to the SSTF is Heussler Hamburg heliport (OØ1) which is a public heliport currently used for MercyFlight operations. However, the heliport is scheduled to be expanded, reconfigured, and moved slightly south of the existing heliport by approximately December 2003. The Erie County Sheriff helicopter operations will then be consolidated at the same facility. Currently, there is no published instrument approach for the heliport and all approaches and departures are performed visually. In conjunction with the changes above, a new non-precision instrument approach (GPS) is expected to be developed, approved, and published, thus changing the approach/departure airspace corridor.

Mr. Glen Absolom, Chief Treatment Plant Supervisor, and Mr. Ed McDonnell, Director of Flight Operations for MercyFlight of Western New York have each indicated their willingness to work with E&E on this project. Ed McDonnell has been particularly accommodating.

An FAA study regarding the alteration of this heliport and the new GPS instrument approach is due in January 2003 (according to Ed McDonnell). This study may further clarify some remaining issues, such as the new heliport location and size, the orientation of the GPS approach, and the construction schedule.

Figures. In this analysis, I have used the applicable “Obstacle Evaluation Surfaces” as per FAA FAR Part 77 and FAA Advisory Circular 150/5390-2A, “Heliport Design”. These imaginary Obstacle Evaluation Surfaces have been oriented with respect to an estimate of the prevailing wind (230º True) and as per Ed McDonnell’s suggestions. I have included both red and yellow shaded areas on Figures 1 and 2. The red shaded areas indicate where a 165-foot tall structure would penetrate (i.e. “violate”) the imaginary surface. The yellow areas indicate where a 165-foot tall structure might fit “underneath” the imaginary surface.

Note that Figures 1 and 2 are approximate, intended for initial planning purposes only, not for navigation or FAA certification. When FAA Form 7460-1 is filed, an official USGS map and a registered surveyor are required (see below for more details).

Figure 1 describes the visual approach/departure “Obstacle Evaluation Surfaces” for the existing heliport. Currently, there is no published instrument approach. Figure 1 will be valid until the new heliport and non-precision instrument (GPS) approach are completed and operational, sometime around December 2003. Figure 2 describes the non-precision (GPS) approach/departure “Obstacle Evaluation Surfaces” for the relocated and expanded heliport, to take effect around December 2003. On both figures, the approach is from the east (right) and the departure is to the west (left). Note that, in Figure 2, the shaded areas are much larger than in Figure 1 (and no yellow areas are visible at all) and the helipad area is larger and aligned with the approach/departure corridor. It is obvious that there are many more options for tower placement in Figure 1–before the heliport relocation and expansion are completed. Again, keep in mind that, on both figures, all imaginary evaluation surfaces (shaded areas) are approximate. Also, on Figure 2, the new heliport’s size, location, and configuration are approximate (the edge of the new helipad will be located roughly 25 feet from the SSTF property line). For both figures the scale error is about ±100 feet at worst, ±50 feet at best.

Given the above, to avoid delays and problems, I recommend that these imaginary surfaces should be avoided both vertically and horizontally. That is, I recommend that any proposed structure should not only avoid penetrating an imaginary surface (the red shaded areas) but should also not be placed “underneath” the imaginary surface (the yellow shaded areas). Placing the meterological tower as far south and east as possible will minimize interference with heliport operations, provide more room for the tower's guy wires, and maximize chances for FAA approval (i.e. determination of no hazard to air navigation).

Notification. FAR Part 77 requires that the FAA be notified of certain proposed construction near a public use heliport. FAA Advisory Circular 150/5390-2A and FAR Part 77.13 indicate that proposed construction of structures "more than 200 feet AGL or less than 200 feet AGL and located within 5000 feet of a public use...heliport and penetrate a 25:1 sloping surface originating at the heliport..." require notification.

This imaginary sloping surface reaches 165 feet above the heliport surface at 4125 feet from the heliport. All of the property of the SSTF is well within this distance (indeed, all the land area shown in Figures 1 and 2 is well within this distance).

Thus, the FAA must be notified, even though the structure, at 165 feet, is below 200 feet.

Given this, according to FAR Part 77.17, "each person...shall send one executed form set [four copies] of FAA Form 7460-1, Notice of Proposed Construction or Alteration, to the Manager, Air Traffic Division, FAA Regional Office having jurisdiction over the area within which the construction or alteration will be located." As stated earlier, this must be done at least 30 days before (1) the start of construction or (2) the date an application for a construction permit is to be filed, whichever is earlier. I have included contact information below. See FAA Form 7460-1 (and instructions) for more information.

To complete Form 7460-1, you'll need to get a copy of the appropriate USGS 7.5 minute quadrangle map for the area and you'll need to hire a registered surveyor to indicate precise latitude/longitude coordinates. The USGS map costs roughly $50 and will take approximately 1-3 days for an electronic delivery (FTP) or approximately 1-3 weeks for a physical delivery. See the USGS mapping website (listed below) for more information.

FAA Acknowledgment/Determination. As per FAR Part 77.19, the FAA acknowledges in writing the receipt of each notice submitted under Part 77.13(a). In this acknowledgment, the FAA will determine that the construction (1) would not be a hazard to air navigation or (2) would be a hazard to air navigation. If it is determined to be a hazard, further study may be requested within 30 days to confirm or refute this.

The FAA acknowledgment may also include information (as per FAR Part 77.19) on how the structure should be marked and lighted in accordance with FAA Advisory Circular 70/7460-1. Ed McDonnell of MercyFlight requested that, if lighted, the tower use red omnidirectional lights, *not white strobes*.

Also, according to FAR Part 77.13, in their acknowledgment, the FAA may require supplimental notices 48 hours before the start of construction or within five (5) days after the structure reaches its greatest height. If the FAA notifies that one or both supplimental notices are required, use Form 7460-2.

As per FAR Part 77.39, unless otherwise extended, revised, or terminated, an FAA determination of no hazard "expires 18 months after its effective date, regardless of whether construction has started, or on the date the proposed construction...is abandoned, whichever is earlier."

Contact Information & Sources

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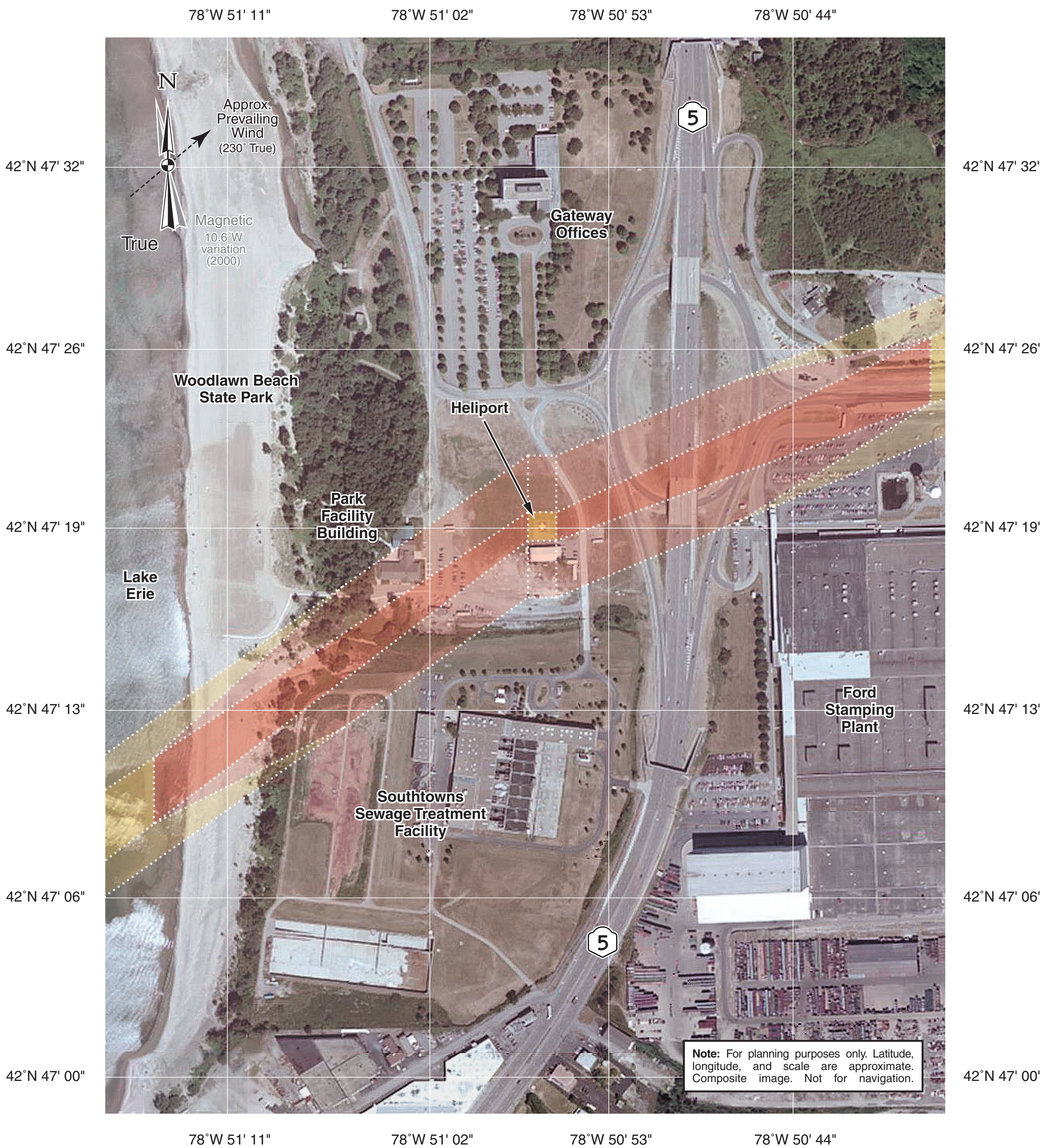
Fax: (718) 995-5693
Employee Locator: (202) 366-4000
Email: 9-AEA-520@faa.gov
Website: http://aea.faa.gov

- FAA FAR Part 77 (attached)
- FAA Advisry Circular 150/5390-2A (attached)
- FAA Advisry Circular 70/7460-1 (attached)
- FAA Form 7460-1 & instructions (attached)
- FAA Form 7460-2 (attached)
- FAA Detroit Sectional Aeronautical Chart, 63rd edition
- FAA Airport/Facility Directory NE, effective 8 Aug 2002 to 3 Oct 2002
- United States Geological Survey (USGS) mapping website: http://mapping.usgs.gov
- MapQuest/GlobeXplorer: http://www.mapquest.com
- Terraserver: http://terraserver.com

Obstacle Evaluation Surfaces: Visual Operations

Huessler Hamburg Heliport (OØ1), Prior To December 2003



500 feet

Approach/Departure > 165'

Transitional > 165'

Approach/Departure < 165'

Transitional < 165'

Helipad (FATO Area)

Proposed Takeoff/Landing Area (TLOF)

Figure 1

Obstacle Evaluation Surfaces: Nonprecision Instrument Operations

Huessler Hamburg Heliport (OØ1), Proposed Renovations, Post December 2003

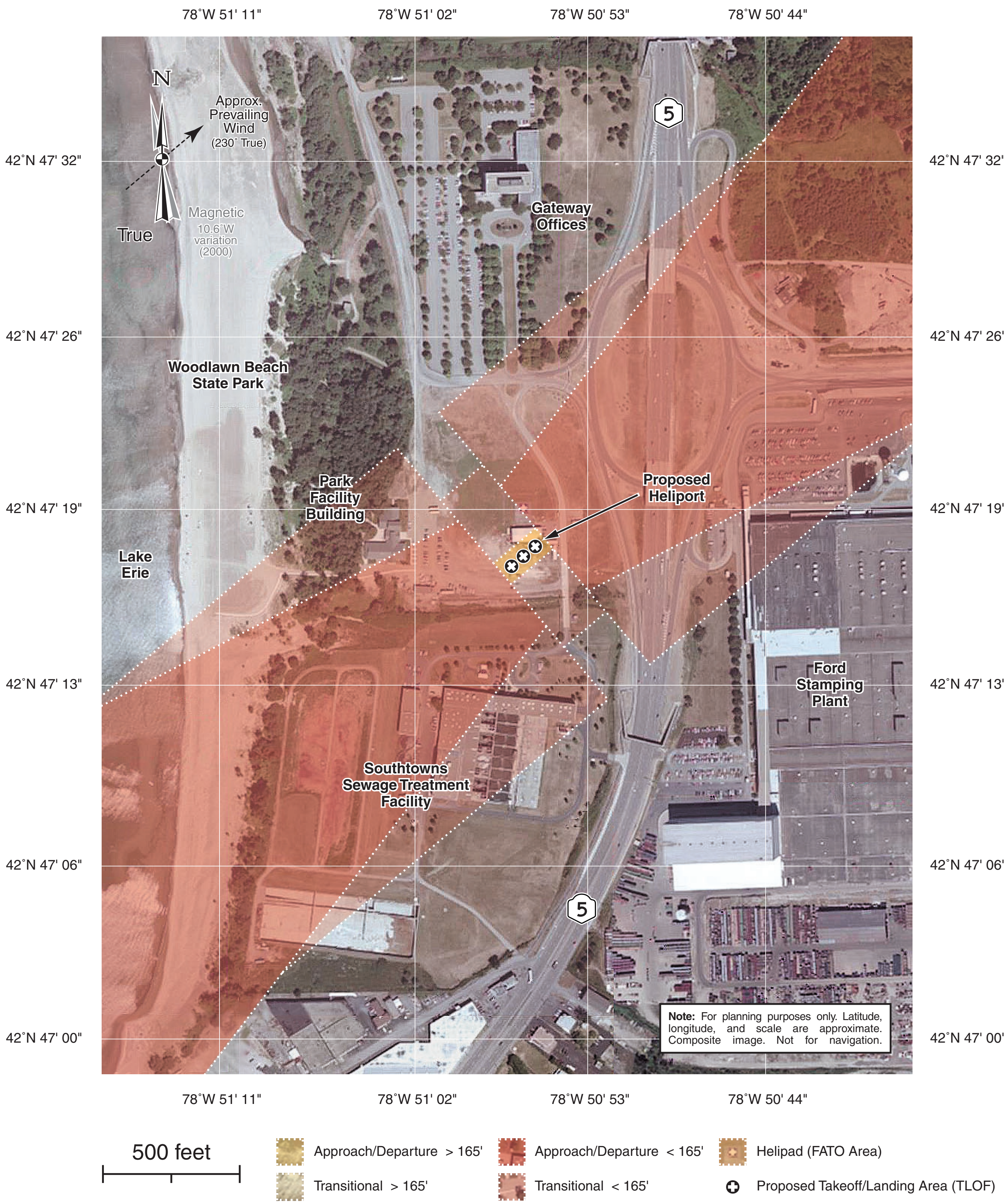


Figure 2

APPENDIX D

AWS TRUEWIND, LLC SODAR REPORT

Report on Sodar Measurements on the Buffalo Shoreline
For Ecology and Environment, Inc.

AWS Truewind, Inc.
Revised October 15, 2004

Executive Summary

A sodar was installed at 2 sites along the Lake Erie shoreline in Erie county, NY. The instrument was operated at the Southtowns Sewage Treatment Plant site from November 7 to December 6, 2003 and from December 10 to December 26 at the NFTA tower site. At the Southtowns Sewage Treatment plant site, 60 m and 80 m wind speeds were the same as NFTA for speeds above 5 m/s. At other heights and other speeds, NFTA was 2-3% windier. The slope of the regression line indicates that NFTA was 7% windier. However, these differences in wind resource are all within the 8.5% uncertainty that results when making long-term speed estimates based on such short-term measurements. Consequently, no statistically significant difference in wind resource can be identified between the two sites. At the NFTA tower site, the slope of the regression line indicates that the 60 m sodar speeds were 3 % less than those on the tower. However, the wind direction during the sodar campaign was not necessarily representative of the long-term wind rose. When the wind speed estimates are adjusted for the long-term directional distribution, the long-term adjusted speed ratio was 1.0, indicating equal wind resource. The R^2 values for regressions with the NFTA tower were much higher when the sodar was located at the NFTA site. At both sites there was closer agreement with the tower wind speeds when the winds were onshore, with a trajectory over Lake Erie. Tower and sodar measurements agree that there is very low shear (0.1 to 0.16) above 60 m for onshore winds. Both sites are very inhomogeneous and rough for offshore winds, due the industrial/urban nature of the sites.

Introduction

A sodar system was installed and operated by AWS Scientific at two sites on the Lake Erie shoreline in Erie County, NY. The objective of the sodar study was to measure the mean wind and wind shear profiles within the atmospheric layer that large-scale wind turbines operate. The sodar profiles were then compared with measured and extrapolated profiles from the Niagara Frontier Transportation Authority communications tower fitted with cup anemometers at 28, 59 and 105 m. This report summarizes the results obtained at the two locations on the Lake Erie shore.

Site Description

Sodar measurements were made at 2 sites along the Lake Erie shoreline in Erie County, NY. The first location was at the Southtowns Sewage Treatment Plant (Figures 1 and 2) at 42.7851 N 78.8489 W. The second was on the site of the Niagara Frontier Transportation Authority (NFTA) communications tower (Figures 14 and 15) at the Buffalo Port Terminal; the sodar location was 42.8561° N 78.8694° W. At Southtowns the sodar was approximately 90 m SSE of the treatment plant, in a large grassy area. At the NFTA site the sodar was located approximately 176 m SSE of the communications tower; NYS Route 5 passes close by to the E of both sites. The Southtowns site is surrounded to the N, E and S by urban/industrial development, including a Ford stamping plant to the E.

The sodar model used was the Atmospheric Research & Technology (ART) VT-1. The system was run on A/C power at both sites. The configuration of the anemometry on the NFTA communications tower is given in Appendix A. Averages and standard deviations for both sodar and tower were logged at 10-minute intervals.

Data Quality

The sodar employed had undergone a series of calibration and quality control checks within 10 days of its installation at Southtowns, using ART's *SodarTools* calibration software and other metering devices. These tests were repeated on November 19 after the sodar was re-oriented and the new hard disk installed. The calibration exercises included: testing the sensitivity of the sodar to frequency shifts, the antenna element output amplitude, the sodar pulse waveform output, amplifier gain and wave balance adjustments, and transponder testing. The sodar determines the wind speed from the Doppler shift in frequency; the sensitivity for this instrument is 0.14 m/s per 1 Hz frequency shift for horizontal wind components, and 0.04 m/s per 1 Hz for the vertical velocity component. The sodar can resolve a frequency shift of 1 Hz.

Data were obtained every 1 to 3 days via cellular telephone and modem. Synchronization of sodar data with tower data was verified by plotting time series of the wind direction for both instruments; there was no need to adjust the time of either dataset before integrating them, except to account for the fact that the sodar reports time at the end of each averaging period, and the NRG logger reports time at the beginning.

The sodar computer hard drive failed at the time of installation at Southtowns, on November 7. A temporary replacement hard drive was installed at that time. By the time a permanent replacement was installed on November 18, it had been determined that the data at this site were being affected by a fixed echo from the sewage treatment settling tanks. Although the wall of the building was only 10 degrees above the horizon, the echoes from it were being detected by the sodar. The problem was mitigated on November 18 by translating the sodar a few meters to the E, and turning it about 45 degrees, so that sodar sound pulses that reached the building would be reflected away from the sodar.

In addition to the above, the following data quality screening of the data were performed:

1) Periods of precipitation, as measured with a rain gauge logged with the sodar data, were removed, as well as any periods when the signal-to-noise ratio in the sodar return signals at the 50 m level were less than 10. In addition, periods when the return signal amplitude at 30 m was less than 900 were removed.
2) Signal amplitude profiles were examined for fixed-echo effects.
3) The sodar measures the 3 components of the velocity (u,v,w) separately by correcting the horizontal components for the influence of the vertical (w). The sodar thus reports a vector wind speed, while the tower anemometers report a scalar wind speed. Conversion of the sodar vector speeds to scalar speeds was accomplished by using a conversion routine based on the standard deviation of the wind direction, provided with the tower data.
4) The sodar data have been adjusted for the effect of temperature on the sodar beam tilt angle. This had the effect of increasing the sodar wind speeds by about 3% at each site. In addition, for the purposes of making sodar/anemometer comparisons, the tower wind speeds were adjusted for overspeeding using the sodar vertical turbulence intensity. This adjustment was about 2%.

5) Because not all sodar profiles achieved measurements above 150 m, standardization of the profiles prior to averaging was done. The standardization was done by subtracting the 30 m wind speed from each profile prior to averaging. The mean 30 m value was then added back to the average profile to obtain standardized average profiles.

The sodar operated continuously during each measurement period, with the exception of a period at Southtowns (November 20) when there was a power outage. The total availability of the sodar was 91% at Southtowns. The measurement period at the NFTA site was shortened by a power outage on December 26, but the sodar operated uninterrupted until that point. Using the above techniques to filter the data, mainly rejecting periods of rain or snow, at the Southtowns site there were a total of 1519 sodar profiles meeting the stringent quality criteria (60% of the total). Of these, 944 were qualified samples on the basis of having 50 m wind speeds ≥ 5 m/s. For the two periods at the NFTA site, there were 2343 profiles, of which 45% or 1047 survived the data quality filter. Using the 50 m wind speed to select qualifying samples, there were 914 (87%) meeting this criterion.

Results from the two sites will be discussed separately below. For the Southtowns site, we focus on the results from the period from November 18 on, when the echo interference problem had been resolved.

Results

Southtowns Site

Table 1 presents a summary of wind speed and wind shear statistics over the measurement period at the Southtowns site, for concurrent sodar and tower observations. The statistics in the table are given for all wind speeds and for speeds ≥ 5 ms^{-1} at 50 m, which are more relevant to wind turbine operations. Tower shear is calculated for the 28-to-59 m interval. The sodar shear is computed for both the 30 to 60 m interval, and the 60 to 80 m interval.

Table 1. Mean statistics for all coincident tower and sodar profiles and for profiles where 50 m wind speed (U) was ≥ 5 ms^{-1} at the Southtowns site.

	Sodar		Tower[1]	
	All U	U≥5 ms^{-1}	All U	U≥5ms^{-1}
Mean Speed 30 m (m/s)	6.2	8.4	6.9	8.9
Mean Speed 60 m (m/s)	7.8	10.4	8.0	10.4
Mean Speed 80 m (m/s)	8.2	10.9	8.5	10.9
Mean Speed 110 m (m/s)	8.8	11.6	9.2	12.0
Mean Shear (60/30)	0.33	0.30	0.22	0.23
Mean Shear (80/60)	0.16	0.15		
Number of Profiles	1519	944	1519	944

[1]Tower speeds at 80 and 110 are the extrapolated values obtained using the tower 60/30 shear exponent.

Table 2 differentiates shear exponents by wind direction sector for winds ≥ 5 ms^{-1}, while Table 3 does the same for even windier cases of speeds ≥ 8 ms^{-1} at 50 m. Mean shear values for the lower profile (59/28 for tower and 60/30 for sodar) are given. Confidence limits on the shear parameters at the 95% level are all 0.02 to 0.04, except when the number of observations falls below 60; in those cases the 95% confidence limits are 0.1 .

The mean speed difference between the sodar and tower systems as a function of wind direction at 30, 60 80 and 110 m are also given, where the tower values for 80 and 110 m were extrapolated using the 59/28 m tower shear exponent. The tower and the sodar shears vary by wind direction, according to the roughness variation in the upwind fetch for each. The 80 m wind speeds are comparable for the (NFTA) tower and Southtowns sodar when the wind is onshore, but they are lower for the sodar in those sectors where the wind is offshore.

Table 2. Profile statistics by wind direction sector at the Southtowns site for periods with mean 50 m wind speed ≥ 5 ms^{-1}.

U>=5 ms^{-1}	**0-45**	**45-90**	**90-135**	**135-180**	**180-225**	**225-270**	**270-315**	**315-360**
Tower shear (59/28 m)		0.19		0.45	0.17	0.23	0.17	0.17
Sodar shear (60/30 m)		0.54		0.39	0.45	0.35	0.16	0.18
Sodar shear (80/60 m)		0.45		0.36	0.42	0.06	-0.01	0.03
Mean Sodar-Tower @ 30 m		-1.5		0.0	-3.1	-1.8	1.4	0.3
Mean Sodar-Tower @ 60 m		-0.2		-0.1	-1.9	-0.9	2.1	0.8
Mean Sodar-Tower @ 80		0.3		-0.4	-1.4	-1.4	1.5	0.6
Mean Sodar-Tower @110		0.0		-0.8	-0.7	-2.0	NA	0.3
Number of Profiles		31		227	248	101	284	50

Table 3. Profile statistics at the Southtowns site by wind direction sector for periods with mean 50 m wind speed ≥ 8 ms^{-1}.

U>=8 ms^{-1}	**0-45**	**45-90**	**90-135**	**135-180**	**180-225**	**225-270**	**270-315**	**315-360**
Tower shear (59/28 m)				0.43	0.15	0.21	0.17	0.15
Sodar shear (60/30 m)				0.33	0.31	0.29	0.16	0.17
Sodar shear (80/60 m)				0.33	0.21	0.09	-0.01	0.03
Mean Sodar-Tower @ 30 m				0.3	-5.7	-1.9	1.6	0.9
Mean Sodar-Tower @ 60 m				0.0	-4.7	-0.8	2.3	1.6
Mean Sodar-Tower @ 80				-0.4	-4.5	-1.1	1.7	1.4
Mean Sodar-Tower @110				-0.7	-4.5	-1.8	NA	NA
Number of Profiles				118	39	76	250	17

Winds during the measurement period at Southtowns were dominated by flow from the W and WNW (onshore winds), with a small contribution from the SW (Figure 3). There was good time series correspondence between the 40 m winds for tower and sodar, with the overall slope between the hourly averages of the two measurements equal to 0.97 (Figure 4). Tower and sodar 50 m wind directions were within less than 5 degrees of one another. The wind speed ratio rose (Figure 5) highlights the influence of wind direction on the relationship between tower and sodar wind speed at 60 m. For the southeasterly and northwesterly wind directions, the sodar wind speeds exceeded those at the tower (ratios > 1.0), whereas southwesterly observations had faster wind at the tower. The overall mean speed ratio, adjusted for the long-term tower wind direction distribution, was 1.03.

The overall mean profiles for all speeds and directions (Figure 6) and for periods when the sodar 50 m wind speed was $\geq$ 5 m/s (Figure 7) suggest that the Southtowns site and the NFTA site had comparable wind speeds at least to 60 m. The top anemometer data in the profile plots is from the 110 m anemometer mounted on a boom with 25-degree orientation. To minimize tower shadowing effects, this anemometer was only used for wind directions 270 to 360, and 0 to 135. The measured shear decreases significantly above 60 m at Southtowns, chiefly because of the dominance of onshore winds (with lake surface fetch), in the statistics. Examination of the profiles by wind direction sector (Figures 8 to 11) reveals that the wind speed for overland trajectories is significantly lower at the Southtowns site than at the NFTA site, being closest to the NFTA site speeds for the SSE sector. However, for offshore wind with trajectories over the water, the Southtowns sodar site had wind speeds as great as or greater than the NFTA tower. Given a 60 m speed ratio of 1.03, adjusted for the long-term wind direction distribution, the Southtowns long-term speeds would appear to be comparable to the NFTA site.

Regression of the sodar-measured wind at 80 m on the tower-extrapolated wind at 80 m (for 50 m winds $\geq$ 5 m/s, all wind directions) gave a slope of 0.96 with an R^2 of 0.89. The regression was forced through zero, so no intercept was estimated, because a zero wind speed at the tower site should produce a zero wind speed at nearby sites. The standard error of the regression coefficient was 0.01

Vertical velocities were mostly negative below about 90 m, but offshore winds generated a region of positive vertical velocity above 90 m, possibly related to the interaction of lake-influenced air with air heated by the land. The mean vertical velocity rose for the 70 m level is shown in Figure 12; profiles of the vertical component of the velocity by wind direction are shown in Figure 13.

NFTA Site

Table 4 summarizes the measurements at the NFTA site while the sodar was located there. The shear values and wind speed differences for observations where the sodar wind speed was $\geq$ 5 m/s at 50 m are summarized by wind direction in Table 5, while those cases where the wind speed was $\geq$ 8 m/s at 50 m are summarized in Table 6.

Table 4. Mean statistics for all coincident tower and sodar profiles and for profiles where 50 m wind speed (U) was $\geq$ 5 ms^{-1} at the NFTA site.

	Sodar		Tower[1]	
	All U	$U \geq 5\ ms^{-1}$	All U	$U \geq 5 ms^{-1}$
Mean Speed 30 m (m/s)	8.1	8.9	8.7	9.6
Mean Speed 60 m (m/s)	9.6	10.6	10.0	10.9
Mean Speed 80 m (m/s)	10.1	11.1	9.4	10.2
Mean Speed 110 m (m/s)	10.9	11.9	11.3	12.4
Mean Shear (60/30)	0.24	0.24	0.20	0.20
Mean Shear (80/60)	0.17	0.16		
Number of Profiles	910	778	910	778

[1]Tower speeds at 80 and 110 are the extrapolated values obtained using the tower 60/30 shear exponent.

Table 5. Profile statistics at the NFTA site by wind direction sector for periods with mean 50 m wind speed $\geq$5 ms^{-1}.

U>=5 ms^{-1}	0-45	45-90	90-135	135-180	180-225	225-270	270-315	315-360
Tower shear (59/28 m)				0.37	0.25	0.25	0.14	
Sodar shear (60/30 m)				0.27	0.44	0.22	0.13	
Sodar shear (80/60 m)				0.32	0.34	0.19	0.02	
Mean Sodar-Tower @ 30 m				0.4	-2.1	-1.4	-0.9	
Mean Sodar-Tower @ 60 m				0.1	-0.5	-0.5	-0.2	
Mean Sodar-Tower @ 80				0.0	-0.5	-0.7	-0.6	
Mean Sodar-Tower @110				-0.7	0.5	-1.0	-1.0	
Number of Profiles				29	260	92	393	

Table 6. Profile statistics at the NFTA site by wind direction sector for periods with mean 50 m wind speed $\geq$8 ms^{-1}.

U>=8 ms^{-1}	0-45	45-90	90-135	135-180	180-225	225-270	270-315	315-360
Tower shear (59/28 m)				0.37	0.24	0.25	0.13	
Sodar shear (60/30 m)				0.21	0.38	0.23	0.12	
Sodar shear (80/60 m)				0.26	0.33	0.19	0.02	
Mean Sodar-Tower @ 30 m				0.8	-1.9	-1.4	-0.8	
Mean Sodar-Tower @ 60 m				-0.1	-0.5	-0.5	-0.2	
Mean Sodar-Tower @ 80				-0.5	-0.3	-0.7	-0.7	
Mean Sodar-Tower @110				-1.3	1.2	-1.1	-1.1	
Number of Profiles				11	148	86	281	

During the NFTA sodar study period W winds were predominant, with a significant contribution from the SW and to a lesser extent, NNW (Figure 16).

As would be expected, the relationship between the NFTA tower wind speed and the sodar wind speed at 60 was much stronger when the sodar was co-located with the tower (Figure 17). The overall regression slope for the line forced through zero was 0.97, with an R^2 of 0.98 for the hourly averages.

The 60 m wind speed ratios (Figure 18) illustrate that the SSE trajectory produced winds that were slightly greater at the sodar location than at the tower, as was the case for the Southtowns site. Given the comparable wind speeds for other direction sectors (ratios about 1.0), this raises the possibility that the 60 m anemometer is shadowed slightly by the tower, for SSE winds. The average profile for all wind speeds (Figure 19) and for cases with 50 m winds > 5 m/s show that overall the sodar yielded wind speeds slightly lower than the tower did, at 30 and 60 m. The average profiles by wind direction sector (Figures 21-24) indicate that the agreement between the sodar and tower was better at 30 m than at 60 m, for the NFTA site. Due to the weakening shear above 60 m, the tower 60/30 shear should not be used to extrapolate to 80 or 100 m.

Regression of the sodar-measured wind at 80 m on the tower-extrapolated wind at 80 m (for 50 m winds $\geq$ 5 m/s) gave a slope of 0.96 with an R^2 of 0.95. The regression was forced through zero, so no intercept was estimated, because a zero wind speed at the tower site should produce a zero wind speed at nearby sites. The standard error of the regression coefficient was 0.01

Conclusions and Recommendations:

The shoreline at each site is oriented differently, so that WSW winds at the NFTA site are onshore winds, whereas at Southtowns these winds have a trajectory over land. This is reflected in the higher shear at the Southtowns site for that sector, which is a consequence of urban development (buildings etc.) to the WSW.

The extremely inhomogeneous environment can produce a wind profile that is quite spatially variable, even over short distances (100 m). We can't completely rule out echo interference as a contributor to the lower wind speeds at each site, because of the large numbers of buildings around with high acoustic impedance, but every effort was made to reduce the impact of echoes on the data.

Vertical velocities indicate the similarity in the two locations with respect to the effects of onshore flow on the vertical velocity profile.

The overall results from the sodar measurements at the Southtowns site suggest that the 80/60 shear exponent for this area should be **0.15**, while the 80/60 shear exponent at the NFTA site should be **0.16**. Results from both sites indicate very weak shear above 60 m, especially for onshore winds. This result is supported by tower measurements for the period outside of the period when the sodar was operating. Wind coming from the landward side is subjected to much more drag from buildings, giving the flow higher shear. Onshore flow at the Southtowns site has 80 m wind speeds as great as those at the NFTA tower, while offshore flow is slowed considerably

An analysis of the seasonal variation in shear at the NFTA tower site was done (Appendix B) in order to generate the long-term adjusted speed ratios and shears. The tower 59/28 shear parameter varies substantially both by wind direction sector and seasonally.

Comparisons between sodar and cup anemometry can be influenced by a number of factors. Most of these have been addressed in the data treatment described in the Data Quality section, above. However, the variable and high surface roughness in the area would lead to a wind field that can vary considerably over relatively short distances. Another factor which may lead to differences between sodar and tower measurements is that the sodar is measuring wind speed in a volume of air, while cup anemometers represent a point measurement.

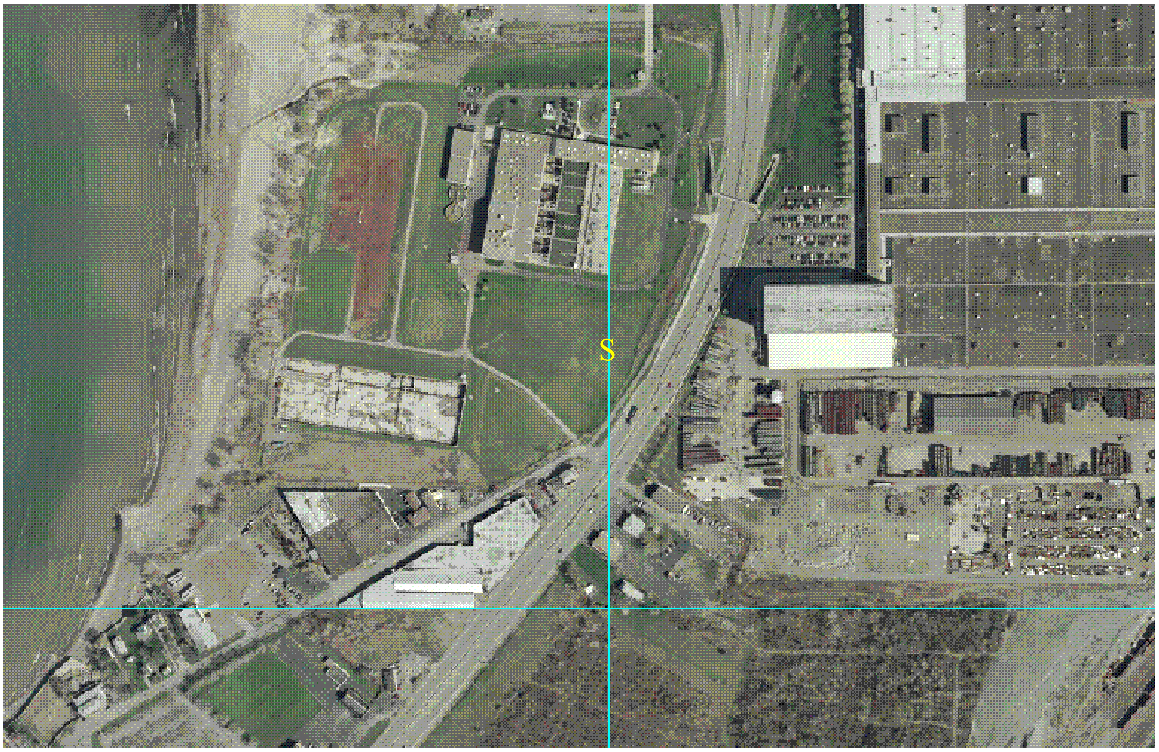


Figure 1. Aerial photo of Southtowns Sewage Treatment Plant. Sodar was in location marked "S".

Figure 2. Sodar installation at the Southtowns Sewage Treatment Plant (Left) Looking NW from sodar location (Right) Looking SW from sodar location .

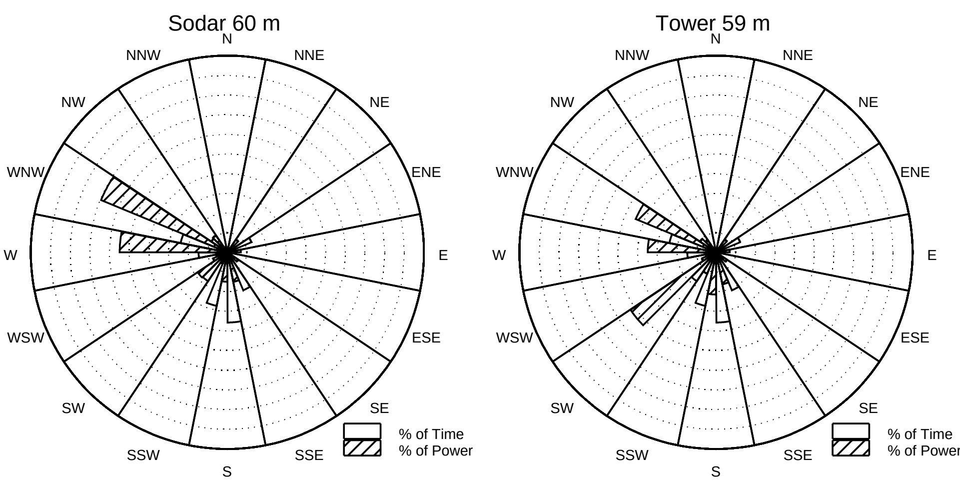


Figure 3. Wind speed and power roses at 60 m for (left) the sodar at the Southtowns Sewage Treatment plant, and (right) for the NFTA tower during the same period . Dotted circles are in increments of 5% beginning with 0% at the center.

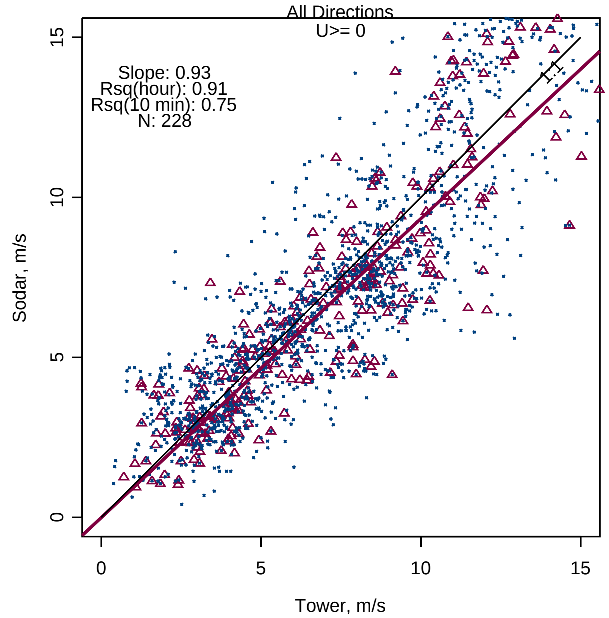


Figure 4. Comparison of tower and sodar 59 m wind speeds, for the Southtowns site. Small blue Xs are individual 10-minute observations, red triangles are hourly averages.

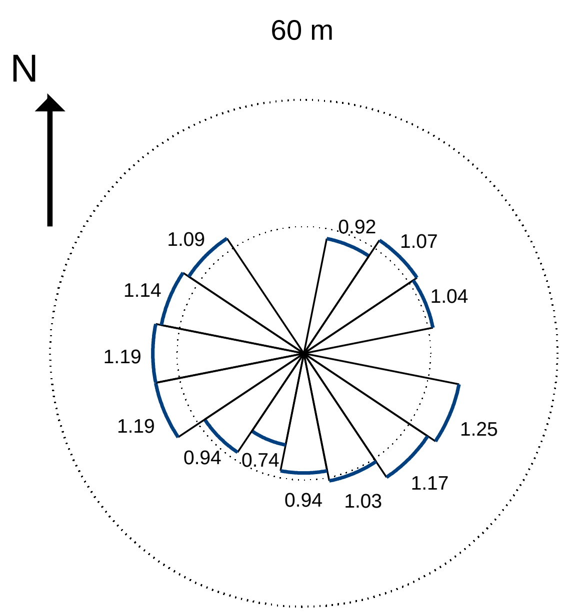


Figure 5. Ratio of sodar 60 m wind speed to NFTA tower 59 m wind speeds by wind direction while the sodar was at the Southtowns site.

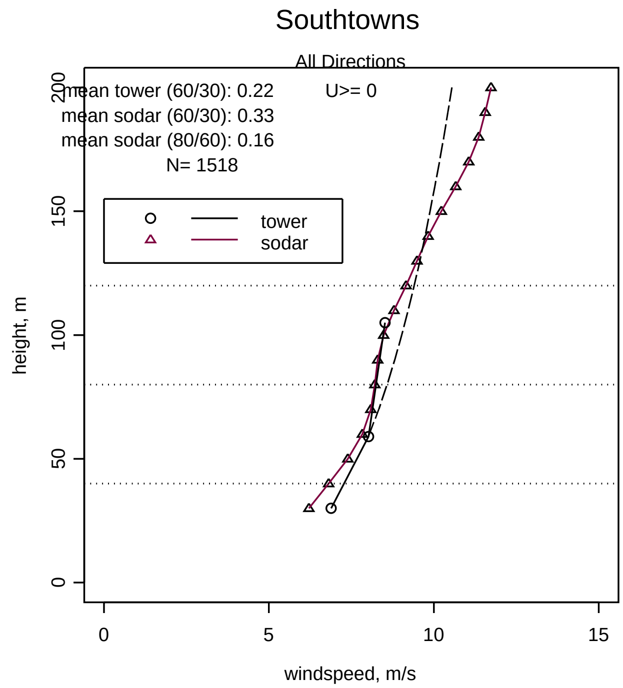


Figure 6.Average wind speed profiles for sodar at Southtowns and the NFTA tower. All wind speeds and directions are included. Extrapolated tower profile (dashed line) is based on the tower 59/28 wind shear exponent.

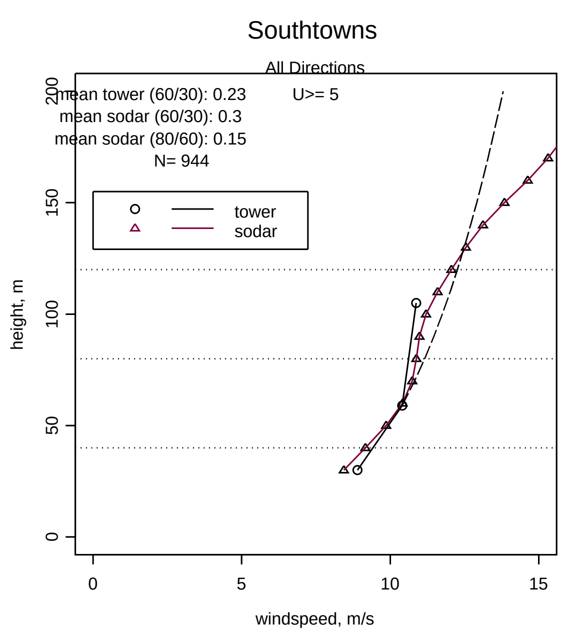


Figure 7. As in Figure 6, except that only profiles with 50 m wind speed ≥ 5 m/s are included.

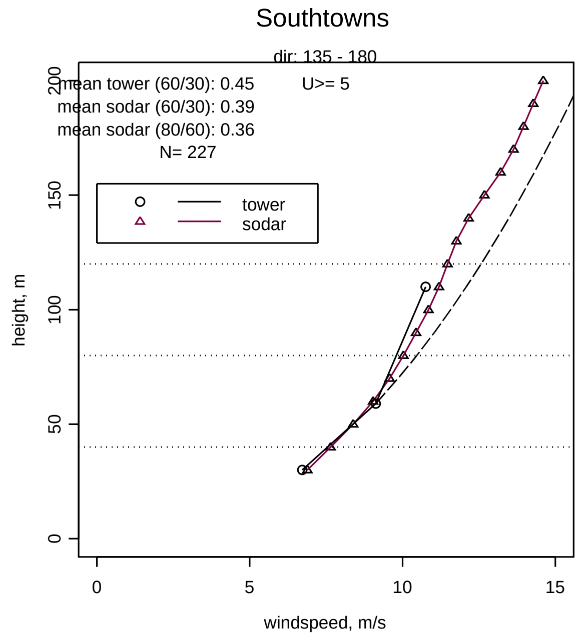


Figure 8. Mean profiles for tower and sodar, for 50 m wind speeds ≥5 m/s, and wind direction from the SSE.

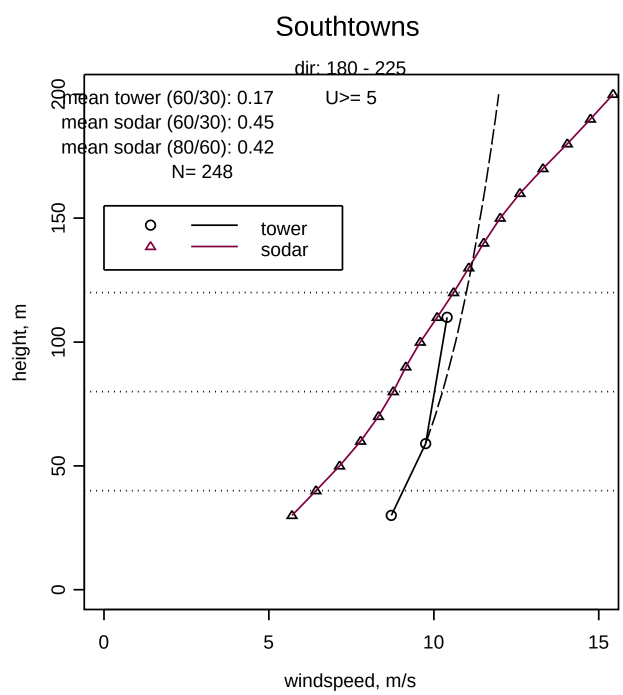


Figure 9. Mean profiles for tower and sodar, for 50 m wind speeds ≥5 m/s, and wind direction from the SSW

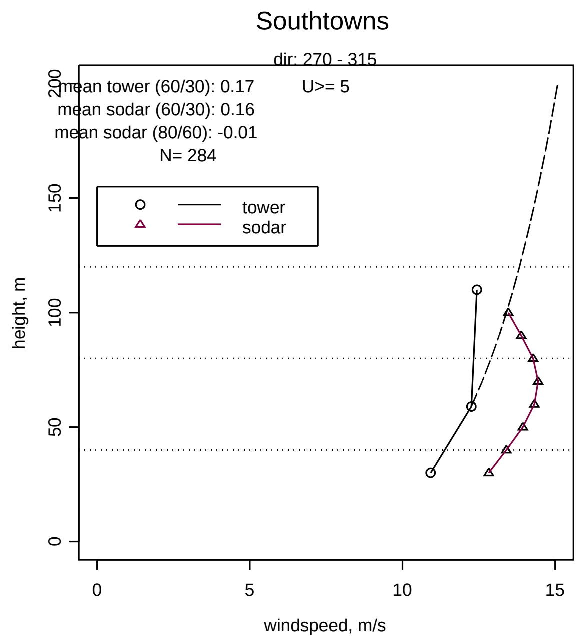


Figure 10. Mean profiles for tower and sodar, for 50 m wind speeds ≥ 5 m/s, and wind direction from the WNW.

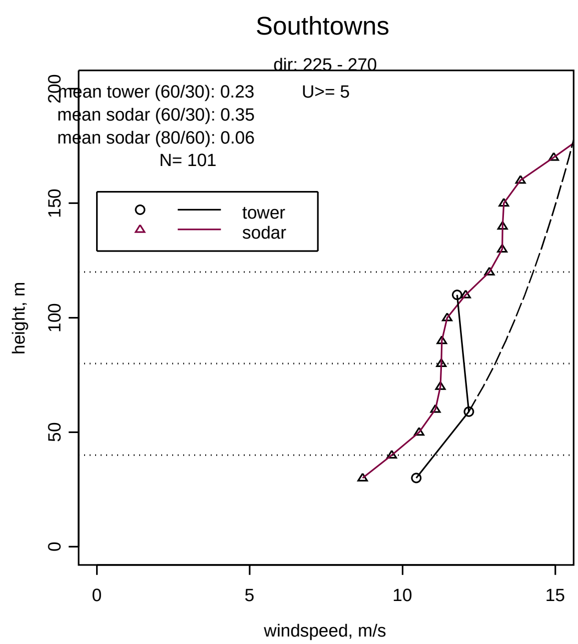


Figure 11. Mean profiles for tower and sodar, for 50 m wind speeds ≥ 5 m/s, and wind direction from the WSW.

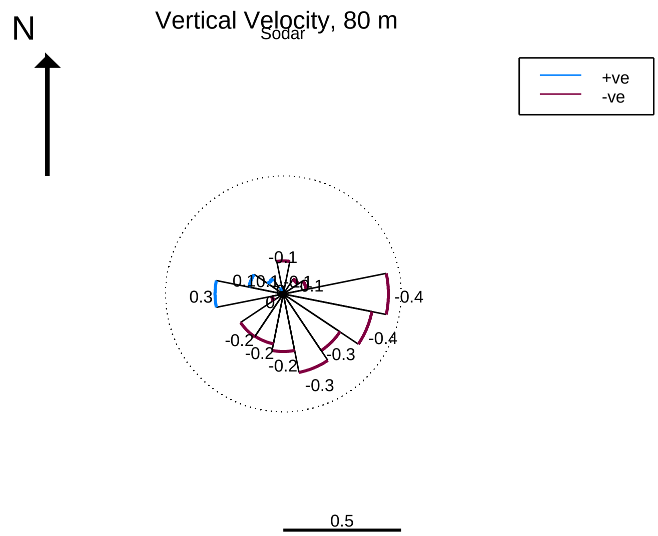


Figure 12. Southtowns mean vertical velocity distribution at 80 m by wind direction sector. Negative vertical velocity is downward, positive is upward.

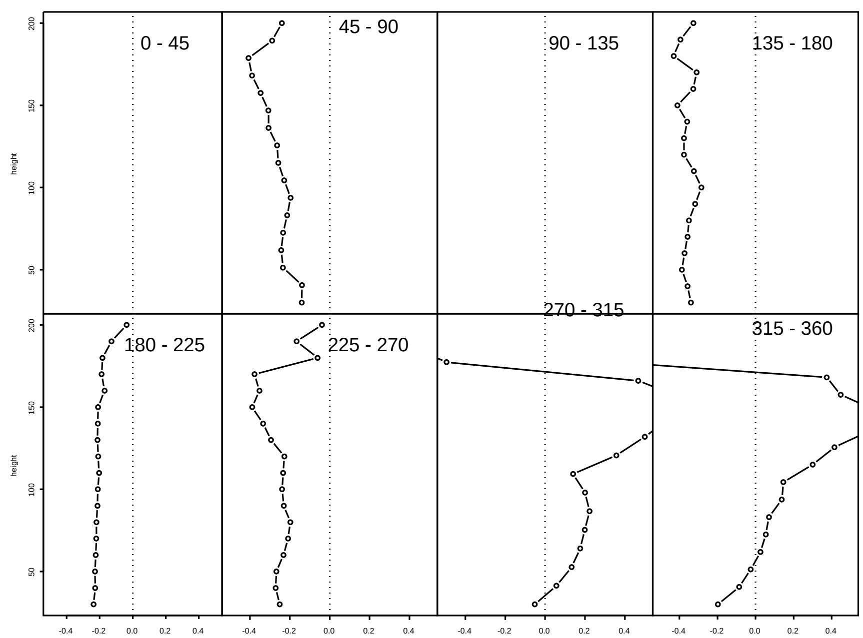


Figure 13. Vertical component of the sodar velocity (m/s) with height (m), by wind direction sector, for all wind speeds, at the Southtowns site. The dotted vertical lines indicate zero vertical velocity. Negative vertical velocity is downward.

AWS Truewind

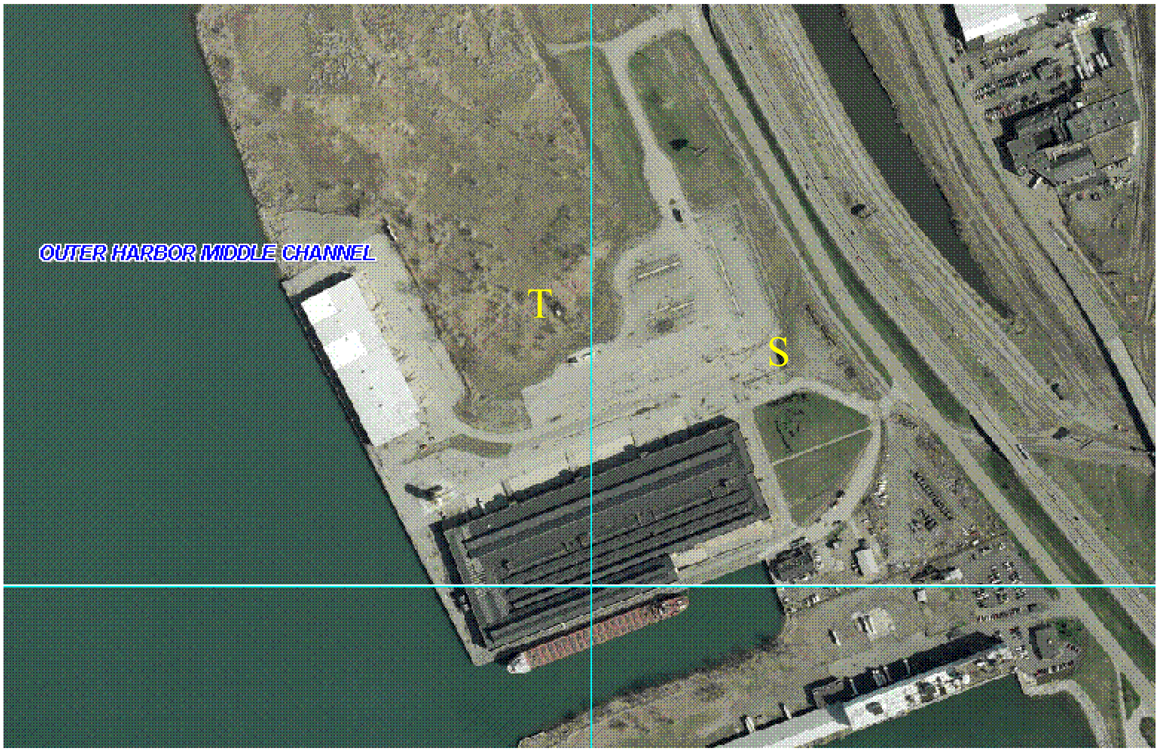


Figure 14. Aerial photo of the NFTA tower site, with sodar location marked "S" and tower location marked "T".


Figure 15. View from sodar location at the NFTA site, viewed looking W (left) and SE (right). NYS Rte 5 passes over the bridge in the photo on the left.

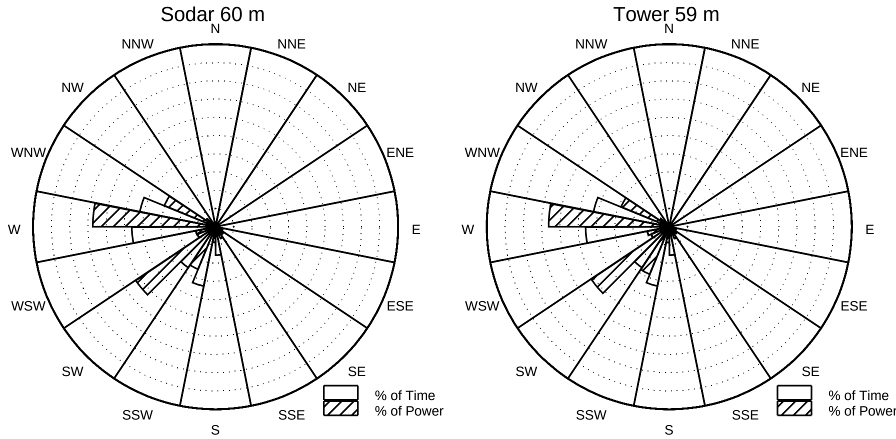


Figure 16. Wind direction frequency rose for all wind speeds during the sodar measurement period at the NFTA site. Dotted lines are in increments of 5% beginning with 0% at the center.

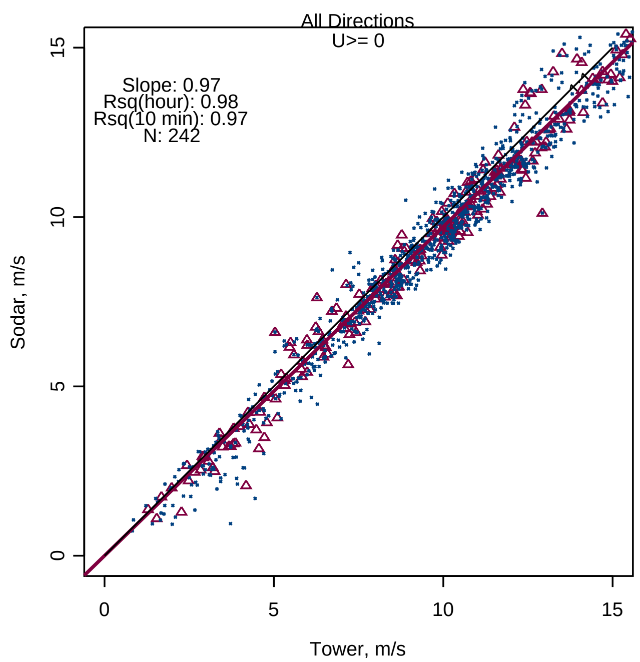


Figure 17. Sodar and tower 59 m wind speeds at the NFTA site, for all wind speeds and directions.

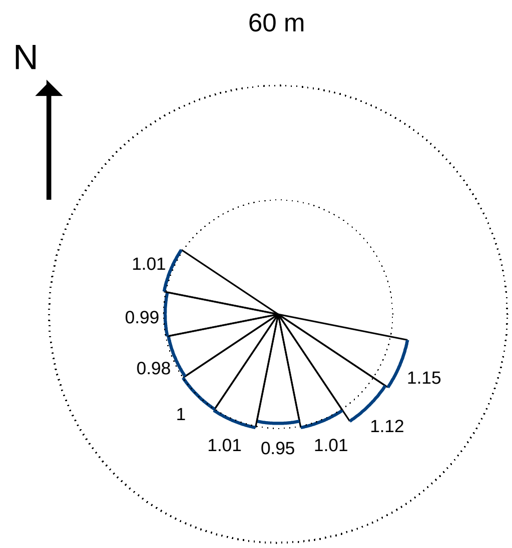


Figure 18. Wind speed ratio rose at 60 m at the NFTA site, for cases where the sodar wind speed at 50 m was ≥ 5 m/s.

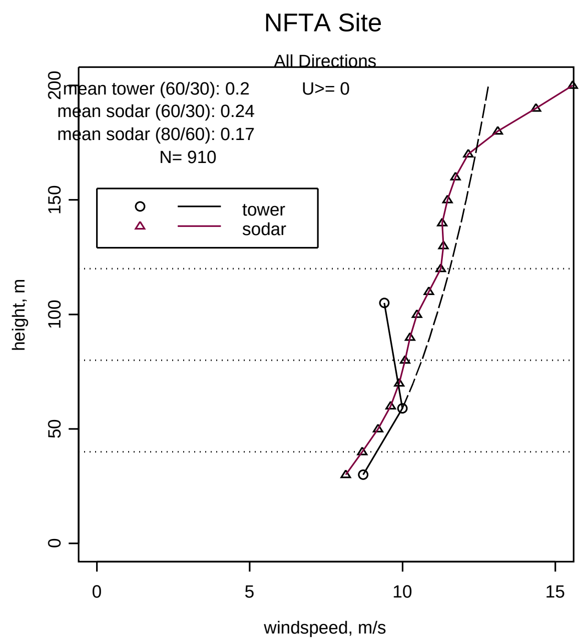


Figure 19. Average wind speed profiles at the NFTA site for all wind speeds and directions.

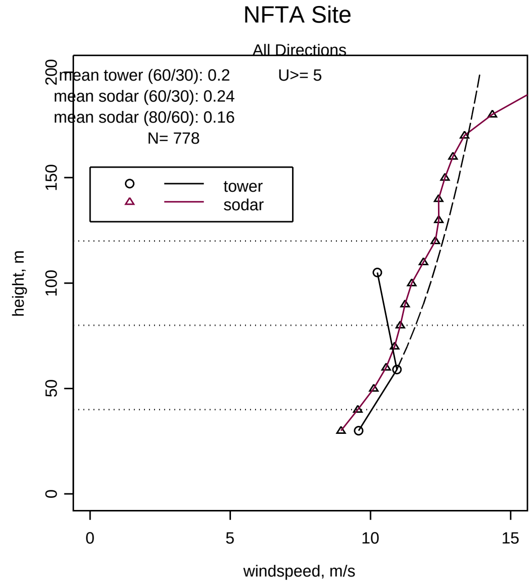


Figure 20. Average wind speed profiles at the NFTA site for cases where the sodar 50 m wind speed was ≥ 5 m/s, for all directions.

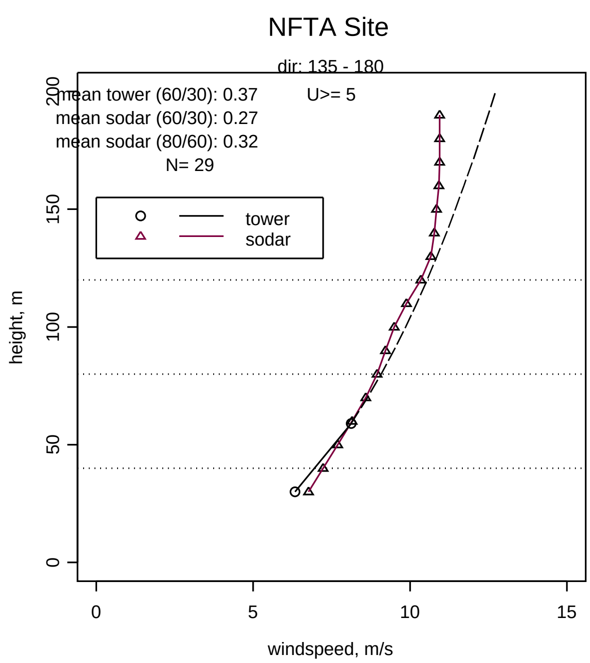


Figure 21. Average wind speed profiles at the NFTA site for cases where the sodar 50 m wind speed was ≥ 5 m/s, and wind was from the SSE.

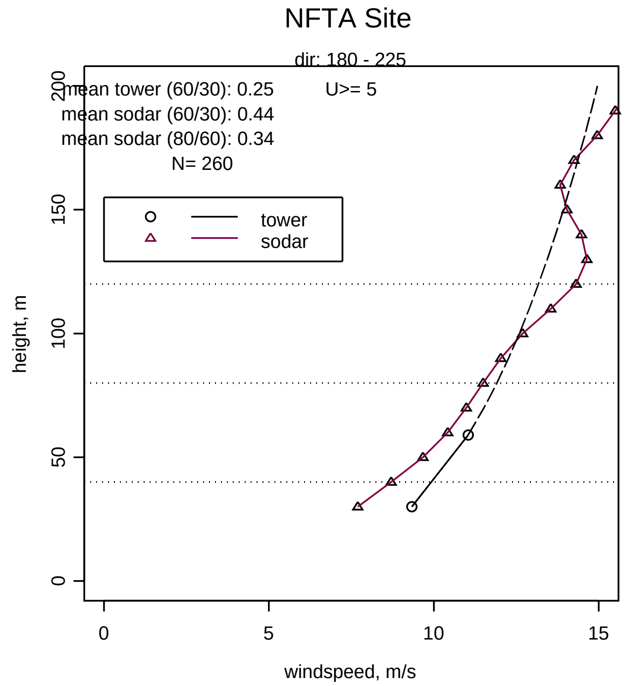


Figure 22. Average wind speed profiles at the NFTAsite for cases where the sodar 50 m wind speed was ≥ 5 m/s, and wind was from the SSW.

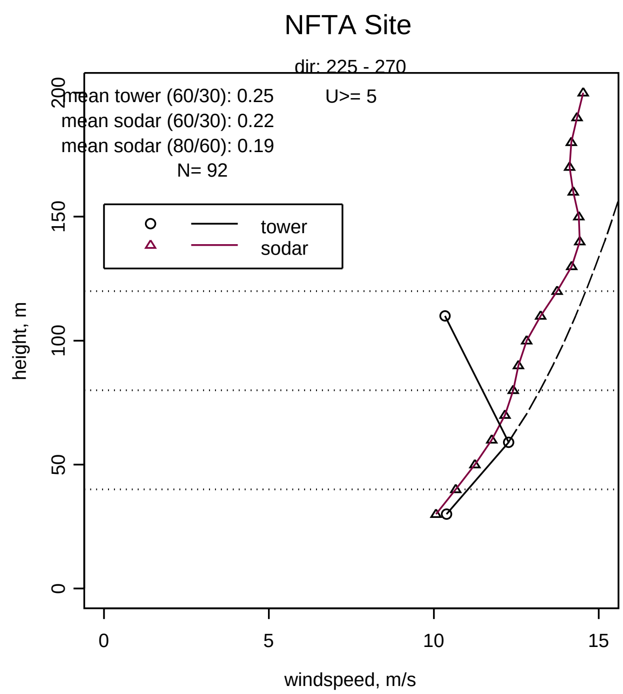


Figure 23. Average wind speed profiles at the NFTAsite for cases where the sodar 50 m wind speed was ≥ 5 m/s, and wind was from the WSW.

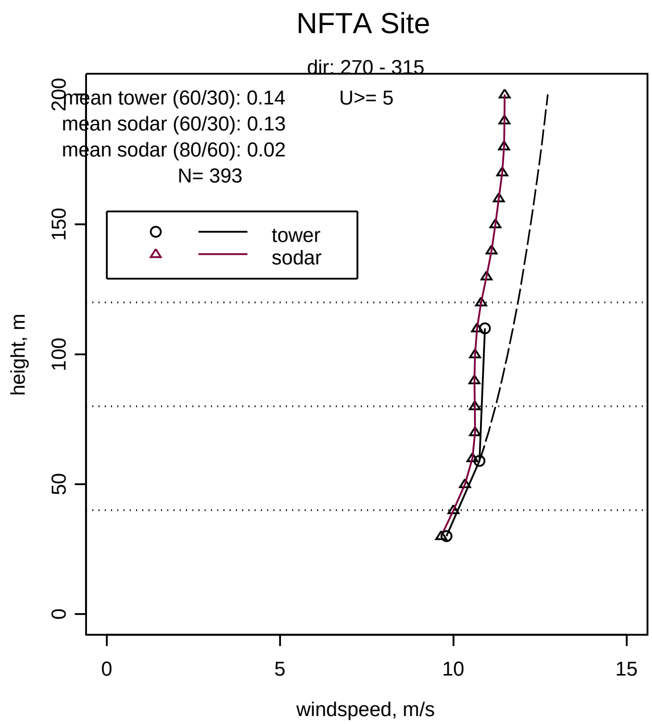


Figure 24. Average wind speed profiles at the NFTAsite for cases where the sodar 50 m wind speed was ≥ 5 m/s, and wind was from the WNW.

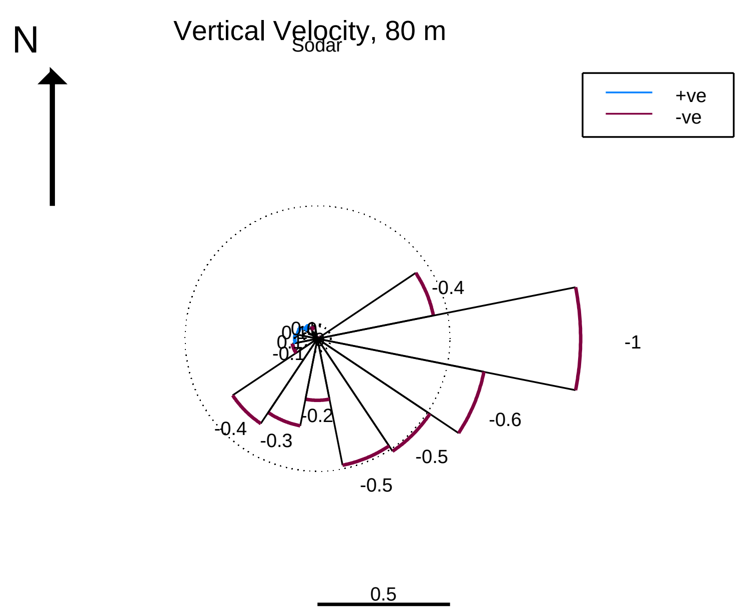


Figure 25. Mean vertical velocity at 80 m, at the NFTA site. Positive (upward) vertical velocities are in blue, negative (downward) are in red.

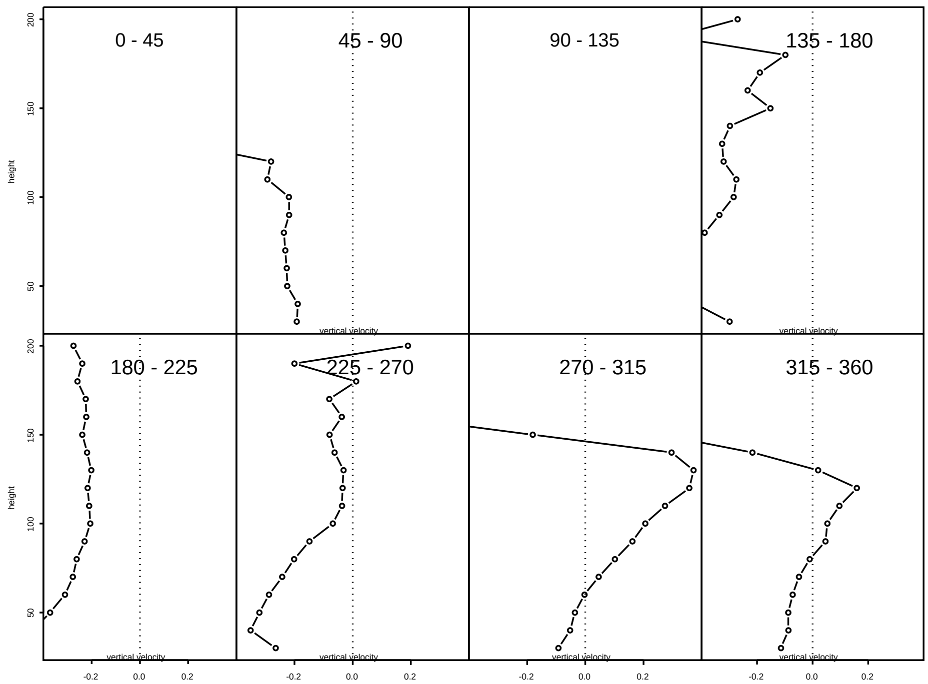


Figure 26. Mean sodar vertical velocity component (m/s) with height (m) by wind direction sector for all wind speeds, at the NFTA site. Dotted vertical lines indicate 0 vertical velocity. Negative vertical velocity is downward.

Appendix A.

Table A1. Location and types of instruments on the NFTA tower during the sodar study period.

Height	Instrument	Boom Direction
110 m	Max-40 Cup	25^o
105 m	Max 40 Cup	205^o
59 m	Max-40 Cup	25^o
59 m	Max 40 Cup	205^o
28 m	Max 40 Cup	25^o
28 m	Max 40 Cup	205^o
28 m	200 P Vane	25^o
58 m	200 P Vane	25^o
65 m	200 P Vane	25^o

Appendix B. Tower wind roses and shear roses by season.

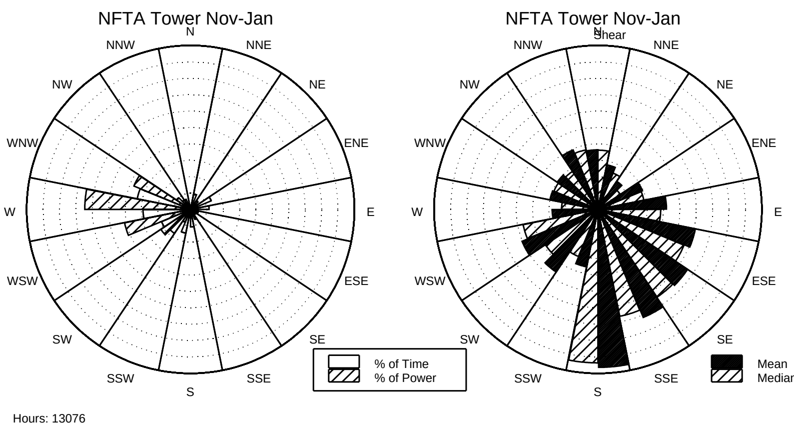


Figure B-1. Tower 59 m wind rose (left) and 59/28 shear rose (right) for the period November 2003 to January 2004. The shear rose shows both the mean shear and the median shear for each direction sector. Dotted lines are in increments of 5% for the wind rose and 0.05 for the shear rose, beginning with 0 at the center.

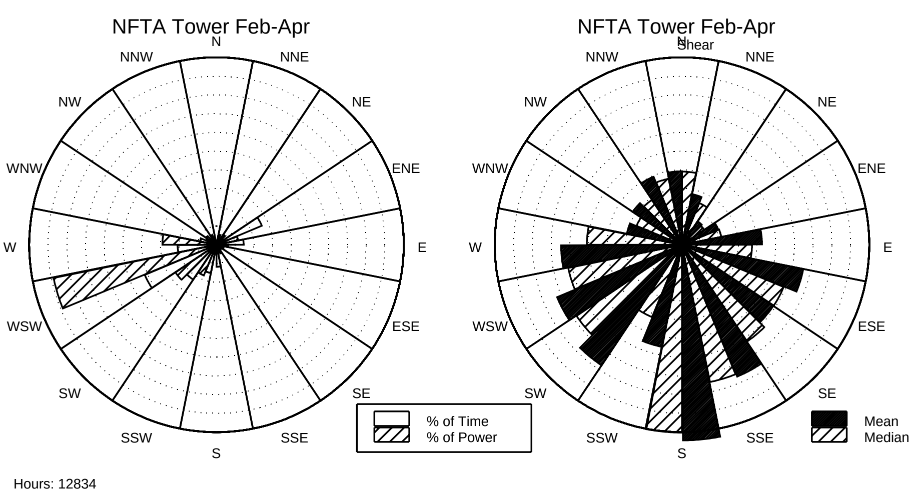


Figure B-2. Tower 59 m wind rose (left) and 59/28 shear rose (right) for the period February 2004 to April 2004. The shear rose shows both the mean shear and the median shear for each direction sector. Scale as in B-1.

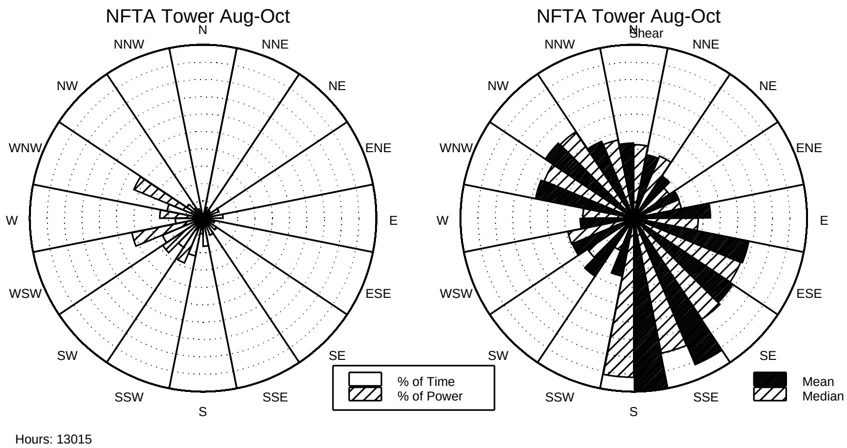


Figure B-3. Tower 59 m wind rose (left) and 59/28 shear rose (right) for the period August 2003 to October 2003. The shear rose shows both the mean shear and the median shear for each direction sector. Scale as in B-1.

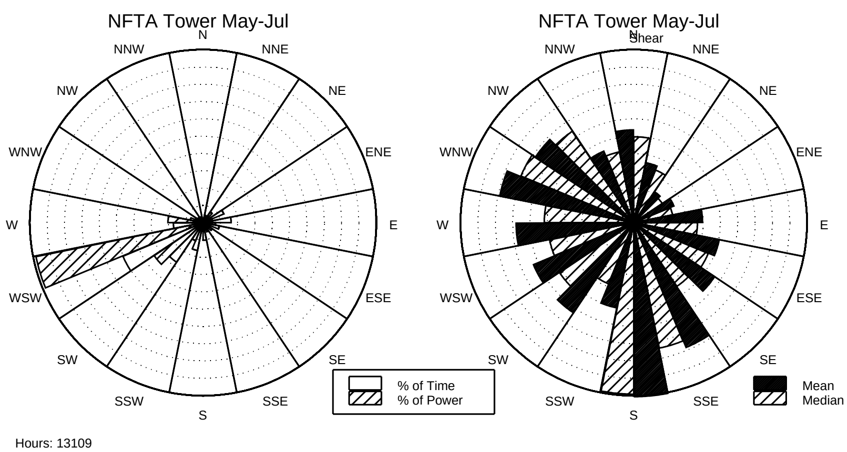


Figure B-4. Tower 59 m wind rose (left) and 59/28 shear rose (right) for the period May 2003 to July 2003. The shear rose shows both the mean shear and the median shear for each direction sector. Scale as in B-1.

APPENDIX E

BUFFALO SHORELINE WIND STUDY SUMMARY REPORT

<u>Report To Ecology and Environment</u>

Buffalo Shoreline Wind Study Summary Report
[July 2003 – August 2004]

Issued 29 October 2004

Revised 23 Feb 2005 to correct NFTA coordinates

Introduction

This report presents the results of a 12-month wind resource measurement study conducted by AWS Truewind, LLC (formerly AWS Scientific, Inc.), in conjunction with Ecology and Environment (E&E) and Erie County for NYSERDA. Five locations along the eastern Lake Erie shoreline were selected for wind resource monitoring. The first site monitored was the Niagara Frontier Transportation Authority (NFTA) tower. Funding for this effort was provided through the U.S. Department of Energy (DOE) via its 2002 State Energy Program. Since the monitoring site is central to this effort and DOE was willing to share this data, the results are included herein. New purpose-built 50 m meteorological towers were installed at the GM, CSX, and ISG sites. The Southtowns site was instrumented with a sodar unit since permission for tower installation was denied due to safety concerns regarding the heliport located nearby.

The monitoring period is characterized with respect to the anticipated long-term wind speed conditions through comparisons with the Buffalo Airport meteorological reference station. Wind speed interpolations/extrapolations to typical hub heights were made using measured wind shear values. These long-term speeds at various likely turbine hub heights were compared with the predictions of the latest New York State wind map completed at a resolution of 200 m. The results show that the map validates well with the measurement results.

This report summarizes a number of important wind characteristics from the met towers, including mean wind speeds, wind power density, wind shear, and prevailing wind direction. The Southtowns sodar results are included here to show how a long-term wind speed estimate is derived for comparison with the wind map. A separate companion report dated 6 July 2004 contains detailed results from the sodar unit.

Site Descriptions

The five sites detailed in this report are all located near the eastern Lake Erie shoreline near downtown Buffalo, NY. The map in Figure 1 details the respective tower locations with reference to the Buffalo Airport and some major roads and highways. Table 1 provides the site details, such as the respective site coordinates, elevations, periods of record, and anemometer heights. Appendix A contains pictures of the monitoring towers and surrounding areas.

Figure 1. Buffalo Regional Map Showing Wind Monitoring Site Locations

Table 1. Monitoring Site Commissioning Information

Site Name	Coordinates	Elevation (m)	Period of Record	Anemometer Heights
NFTA	42° 51' 23.4" N / 78° 52' 19.2" W	172	5/1/03 - 6/30/04	110 m, 59.5 m, 28.4 m
GM	42° 58' 14.9" N / 78° 54' 34.0" W	178	7/3/03 - 8/31/04	48.8 m, 30 m
CSX	42° 50' 19.4" N / 78° 50' 39.4" W	174	8/15/03 - 8/31/04	48.4 m, 30 m
ISG	42° 49' 12" N / 78° 52' 6.8" W	181	8/15/03 - 8/31/04	48.4 m, 30 m
Southtowns	42° 47' 6.4" N / 78° 50' 56.0" W	181	11/7/03 - 12/6/03	N/A (Sodar)

The NFTA tower was located approximately 200 m from the Lake Erie shoreline and about 3.5 km south of downtown Buffalo, NY. On 28 March 2003, monitoring equipment was installed at 67 m, 59.5 m, and 28.4 m on the existing 140 m tower. The upper level monitoring equipment was subsequently moved to up to 110 m on 8 May 2003. The site was operated until the tower was removed in July 2004. The tower was adjacent to a large parking lot for the two-story NFTA shipping and distribution buildings located approximately 200 m south and west of the tower. The building to the west of the tower is approximately

150 m long and situated parallel to the NNW to SSE running shoreline, while the southern building is about 300 m long and runs perpendicular to the shoreline. In general, the buildings affect the tower fetch from the southeast through western prevailing wind directions.

A 50 m meteorological tower was installed at GM on a landfill area at the northeast corner of the Tonawanda Engine Plant. The landfill rose approximately 5 m above the surrounding ground level, with one-story engine plant buildings located to the southwest. A patchy area of 15 m high trees was located northwest of the tower. The tower was commissioned on 3 July 2003, and operated until 1 September 2004. The tower elevation was 178 m, which is about 10 m higher than the level of the Niagara River located about 1.5 km from the tower to the south through west directions.

Another 50 m monitoring tower was installed at CSX and was located just north of the CSX railroad yard, south of Tifft Street, and a little over 1 km from Lake Erie. No buildings were in the tower vicinity as the area surrounding the tower was generally grass, with isolated trees under 10 m in height. The tower was commissioned on 15 August 2003 and operated until 1 September 2004. The tower elevation was 174 m, which is about 5 m above mean lake level. Due to the hard soil and industrial landfill at the site, large concrete blocks were used to secure the tower.

The third 50 m meteorological tower was installed at ISG and was located on the western portion of the old Bethlehem Steel facility. The tower location was about 120 m east of the lakeshore, at an elevation (181 m) approximately 10 m above mean lake level. No buildings were in the vicinity of the tower, as the surrounding area was generally devoid of vegetation due to the industrial landfill at the site. Only isolated trees less than 10 m in height were located northeast of the site. The tower was commissioned on 15 August 2003 and operated until 1 September 2004. As was the case at CSX, due to the hard soil and industrial landfill at the site, large concrete blocks were used to secure the tower.

In order to characterize the wind resource along the Buffalo shoreline from north to south, it was desirable to measure the wind resource near the Southtowns sewage treatment plant. However, aviation safety concerns were soon identified regarding the Mercy Flight helicopter, which used a nearby field as a landing pad. In response, a sodar unit was deployed at this site instead of a met tower. The unit was located in a field about 90 m south of the sewage treatment plant. The Ford Motor Company automotive manufacturing plant is located roughly 150 m east of the sodar location, and the Lake Erie shoreline is about 400 m to the west. No significant trees exist at the site, but it was completely surrounded by single-story light industrial facilities at a minimum distance of a few hundred meters away. The sodar unit operated from 7 November to 6 December 2003.

Tall Tower Data Summary

The tall tower data were transferred to the AWS Truewind offices via e-mail on a regular basis. They were validated to ensure consistency among observations and to check for possible icing conditions during the cold season. Whenever possible, invalid primary sensor data were replaced with concurrent observations from the same-level, redundant sensor. Monthly data reports were prepared and forwarded to Ecology and Environment (E&E)

During the entire monitoring period, all sensors at each tower remained operational – except for the primary 110 m anemometer at NFTA that failed between 28 November 2003 and 18 February 2004. As a result, sensor icing was the only significant source of data loss during the respective periods of record. Some data loss due to tower shadow did occur at NFTA during the period of sensor failure, as the data recovery percentage dropped below 90 % during December 2003 and January 2004. The data recovery percentages are outlined in Table 2.

Table 2 summarizes the important wind characteristics observed at the site during the respective monitoring periods. Among the parameters detailed in the table is the wind power density (WPD), which provides a truer indication of a site's wind energy potential because it combines the effect of a site's wind speed frequency distribution and temporal variations in air density. Average WPD is defined as the wind power available per unit area swept by a wind turbine's blades and is given by the following equation:

$$\textit{Average WPD} = \frac{1}{2n}\sum_{i=1}^{n} \rho \times v_i^{3} \ (\mathrm{W/m^2})$$

where

n = the number of 10-minute records in the averaging interval;
ρ = the air density (kg/m^3); and
v_i^3 = the cube of the wind speed (m/s) at the i^{th} 10-minute average record.

The Weibull distribution is an analytical probability function that can be used to describe the wind speed frequency distribution, or number of observations at specific wind speed values. It has two adjustable parameters (*A* and *k*) that enable it to fit a wide range of probability density functions. *A* is a scale parameter related to the mean wind speed while *k* controls the shape of the Weibull distribution. Values of *k* typically range from 1 to 3.5, with lower values indicating a flatter distribution.

Table 2. 12-Month* Monitoring Site Wind Statistics Summary

Parameter	NFTA	GM	CSX	ISG
50 m Mean Wind Speed (m/s)	7.51 (110 m)	5.35	5.68	7.00
Data Recovery (%)	97.7 %	99.5 %	99.4 %	99.5 %
Prevailing Wind / Energy Direction	WSW / WSW	WSW / WSW	SW / W	WSW / WSW
Wind Shear Exponent	0.192	0.248	0.211	0.177
50 m Turbulence Intensity	0.082 (110 m)	0.151	0.144	0.089
50 m Wind Power Density (W/m^2)	578 (110 m)	182	256	483
Weibull Parameters (A/k)	8.44 m/s / 1.75	6.03 m/s / 2.03	6.38 m/s / 1.75	7.85 m/s / 1.73
50 m Energy-Weighted Air Density (kg/m^3)	1.214 (110 m)	1.225	1.231	1.231

* The period of record presented here is 9/1/03 – 8/31/04; except for NFTA which is 6/1/03 – 5/31/04.

In this region, the 12-month mean wind speeds varied inversely with respect to the site distances from the lakeshore. This is not surprising since widespread urban and industrial development is present in the onshore surrounding area. The result is an abrupt, nonuniform increase in surface roughness, which is undoubtedly the greatest contributing factor to greatly reducing the wind speeds within the first few kilometers onshore.

The regional prevailing wind (and energy) direction is from the west-southwest. This is due to the strong influence Lake Erie has on the regional climate. The only site that doesn't display this exact signature is

CSX, which has a prevailing southwesterly direction and a westerly energy direction. The wind roses are discussed in more detail in the next section.

The mean wind shear exponents (for speeds > 4 m/s) ranged between 0.177 and 0.248 and the turbulence intensity values ranged from 0.082 to 0.151. For both measures, an inverse relationship exists between the parameter and the wind speed. This is not surprising since the higher wind speed sites (NFTA and ISG) are both very close to the lakeshore and the winds are therefore subject to lower surface roughness upwind fetch. Furthermore, it was observed that during the period when Lake Erie was frozen, the wind shear dropped at NFTA and ISG while remaining fairly constant at GM and CSX.

The energy-weighted site air densities were consistent (about 1.23 kg/m^3) throughout the region. This is not surprising given the close proximity of the sites to one another and also the terrain uniformity. The NFTA density appears to be much lower, but the 110 m measurement height is mostly responsible as the 50 m value is about 1.223 kg/m^3. The site air density is important because the amount of energy produced by a wind turbine for a given wind speed is a function of the air density. A 10 % increase or decrease in air density can change the output of a wind turbine by nearly the same percentage.

The wind speed frequency distributions are roughly the same shape, as the Weibull shape parameters are all about 1.75. The only exception is the GM site which has a slightly higher value (2.03); hence, a flatter distribution. This signature is likely due to the much greater overland fetch experienced at GM than at the other sites. NFTA and ISG exhibited similar frequency distributions, as did the CSX despite the lower magnitude wind speed resulting from increased surface roughness. It is possible that while the surface roughness impacts the wind speed magnitudes immediately onshore, the overall distribution shape is more resistant to roughness effects at short distances.

Monthly, Diurnal, and Directional Distributions

Figure 2 is a plot of the monitoring site monthly mean wind speeds. The profiles were very consistent, with the strongest winds observed in January 2004 and the lowest occurring in August 2003. This is not surprising since the strongest winds in this region normally occur between fall and early spring when atmospheric temperature and pressure gradients are greatest.

Figure 3 presents the diurnal wind speed pattern. The highest speeds are observed during the early afternoon hours while – aside from the hours during the rise and fall to and from the maximum – the speeds are fairly constant throughout the day. At NFTA and ISG, there is evidence of a secondary maximum during the overnight hours. It appears that a lake breeze circulation is impacting the region and driving the diurnal profile. This small-scale meteorological phenomenon sets up near the shorelines of large water bodies and is driven by differential heating between the onshore and offshore environments. A temperature and pressure gradient results between the two media and causes increased onshore flow during the day and offshore at night due to differential cooling. The offshore phenomenon is far weaker and the data tend to support this observation.

Figure 4 presents the monitoring site wind roses for the 12-month monitoring period. The concentrated west-southwesterly prevailing direction overwhelmingly suggests the regional wind direction distribution is strongly affected by Lake Erie. Due to the lake orientation and the long open-water fetch, a large majority of the energy producing winds come from between the southwest and west directions. Minimal energy producing winds are observed from other directions because of the urban and industrial development in these upwind directions.

Figure 2. Monitoring Site Monthly Mean Wind Speed Distributions

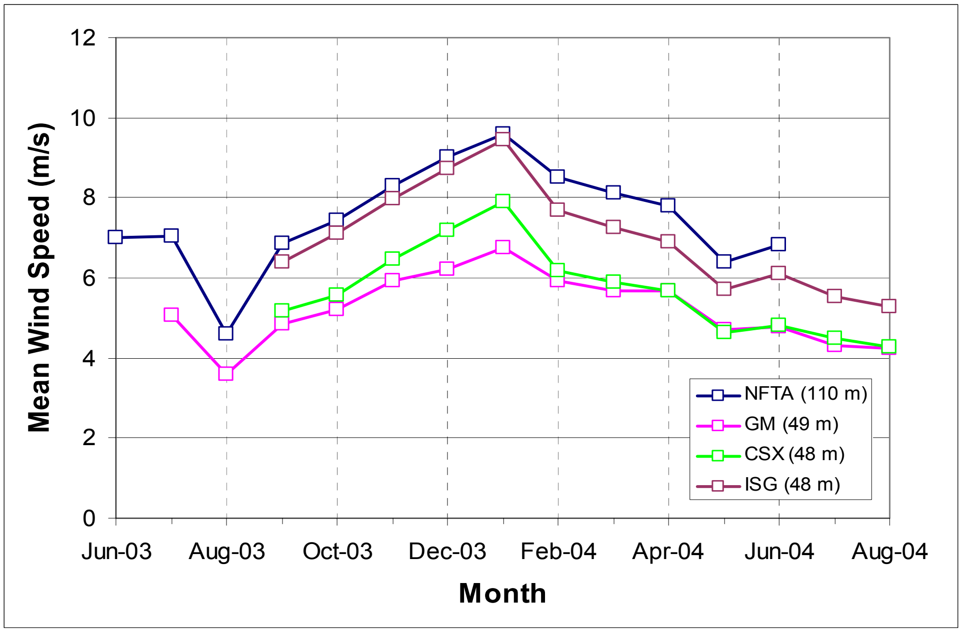


Figure 3. Monitoring Site Hourly Wind Speed Distributions

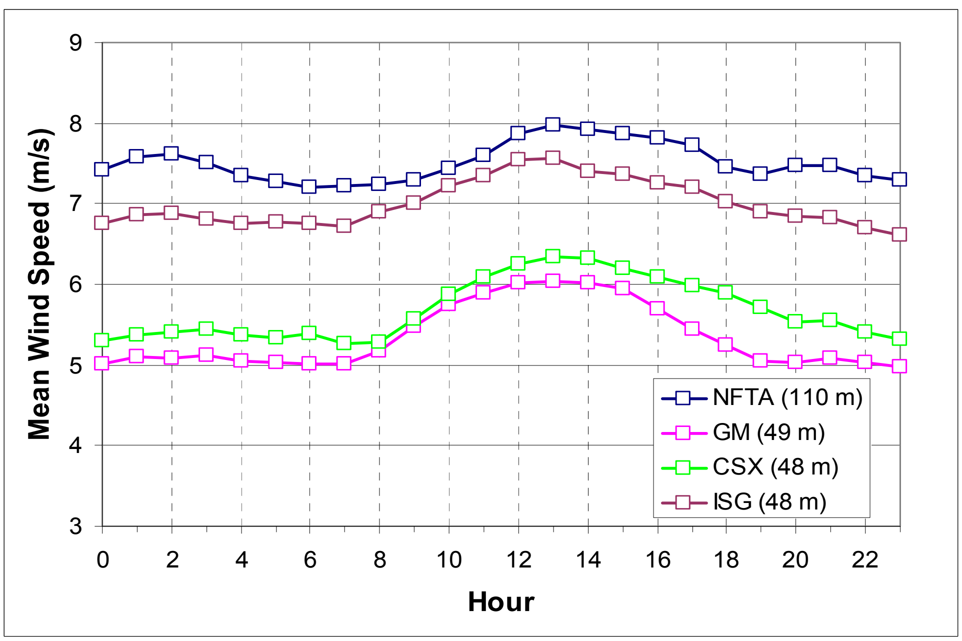
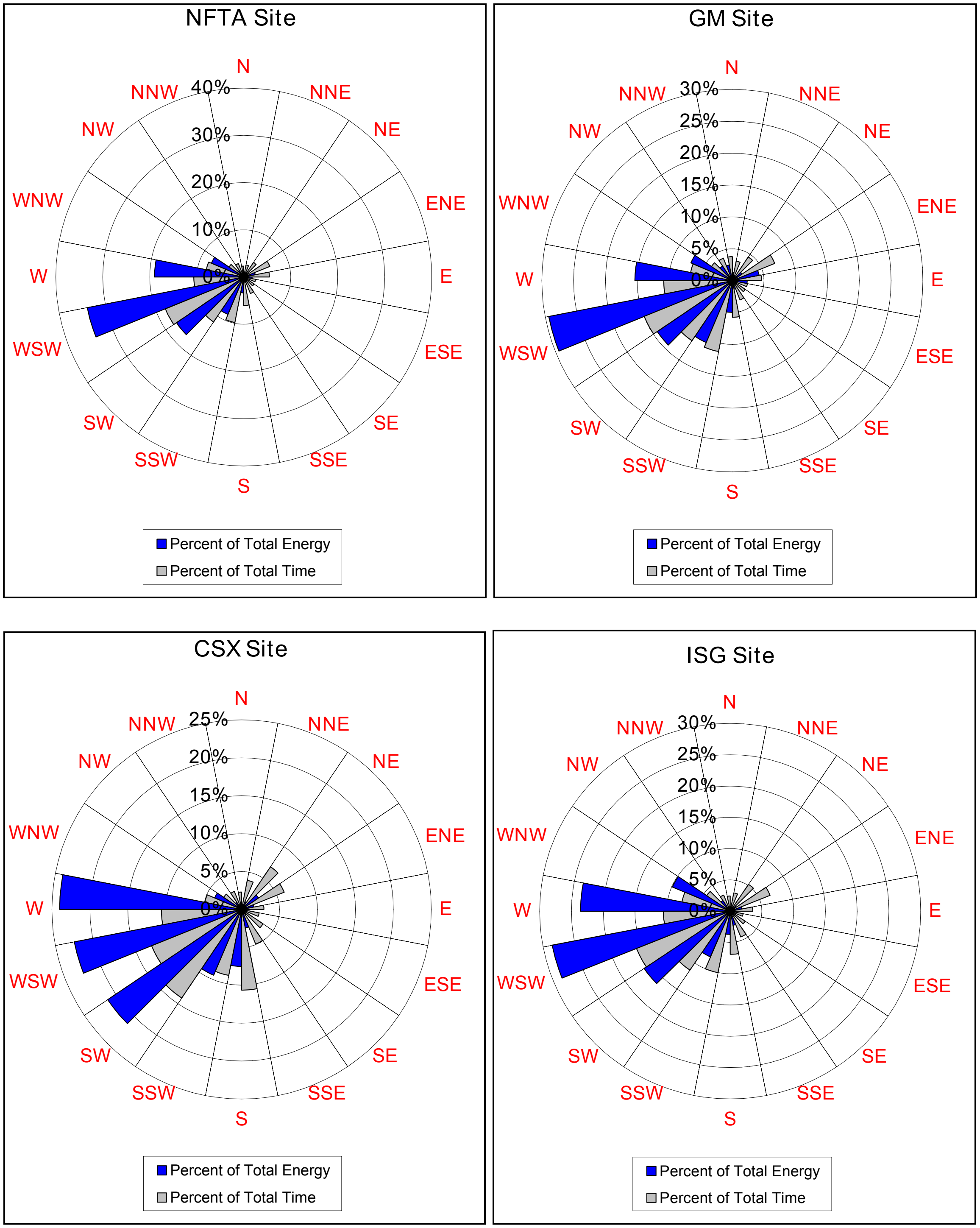


Figure 4. Monitoring Site Annual Wind Roses



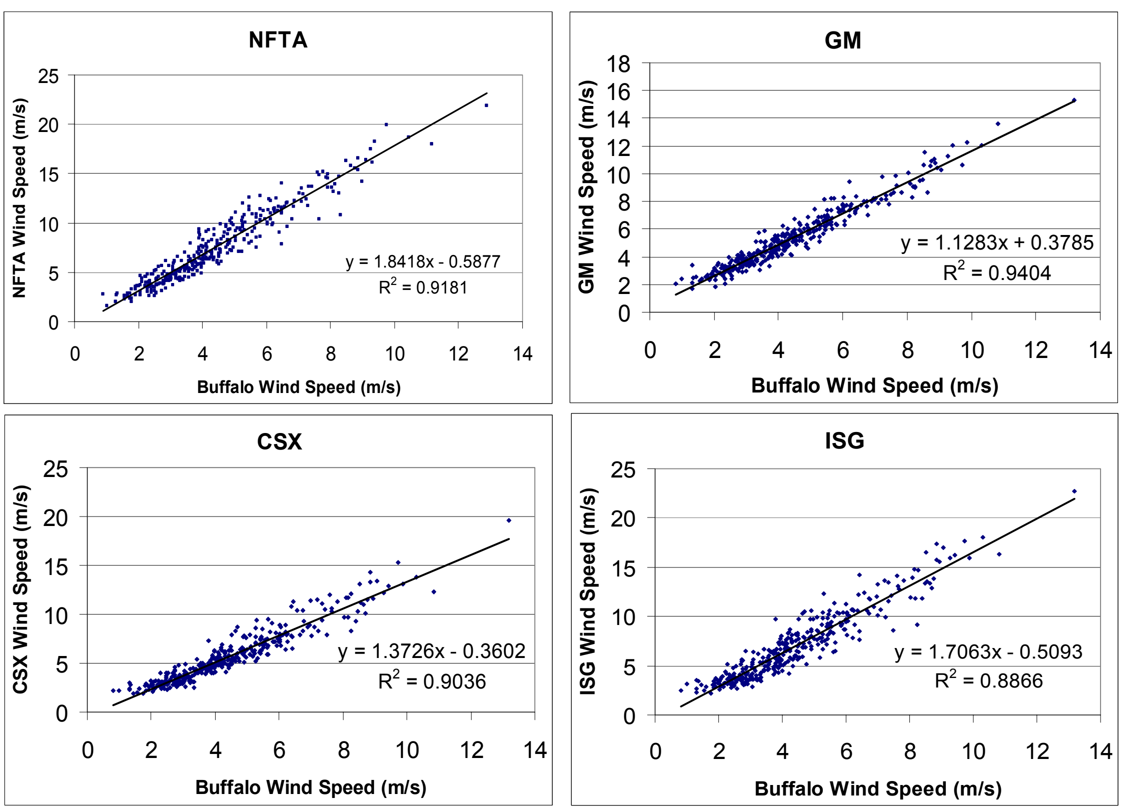
Long-Term Wind Speed Estimate

The monitoring site long-term mean wind speeds were estimated using Buffalo Airport as a reference station because of its close proximity (less than 20 km away) to all of the towers. The Dunkirk Coastal-Marine Automated Network (C-MAN) station was also analyzed and – despite good correlation – was disregarded because of the excellent site correlations with Buffalo. Figure 1 shows the monitoring site locations with respect to the Buffalo airport reference station.

Buffalo Airport wind speed data were obtained for the post-Automated Surface Observing System (ASOS) period (December 1995 to August 2004) to complete the long-term analysis. The National Weather Service upgraded the meteorological equipment at most of the country's weather stations beginning in the early- to mid-1990's. The upgrades included complete replacement of wind sensor models, the relocation of sensors to new 10 m towers (the old tower heights were 6 m), often at different locations on airport grounds, and the use of automated data recording rather than the previous visual, dial-reading technique. This transition has generally resulted in discontinuities in NWS climatological data whereby the post-ASOS wind measurements are generally lower in magnitude (typically 5 % to 10 %) than the average speeds recorded during the pre-ASOS period. These discontinuities generally make it inappropriate to mix the pre- and post-ASOS data records to define the "long-term" average wind speed.

Linear regression analysis was employed to determine the relationship between each respective tower and Buffalo Airport. Concurrent daily wind speed data were used to create scatterplots showing the correlations. They are contained in Figure 5.

Figure 5. Scatterplots of Monitoring Site and Buffalo Airport Daily Wind Speeds



The regression equations developed from the daily mean wind speeds at the four monitoring sites and Buffalo airport are as follows:

NFTA 110 m Wind Speed = Buffalo 10 m speed * 1.8418 - 0.5877 m/s

GM 48.8 m Wind Speed = Buffalo 10 m speed * 1.1283 + 0.3785 m/s

CSX 48.4 m Wind Speed = Buffalo 10 m speed * 1.3726 - 0.3602 m/s

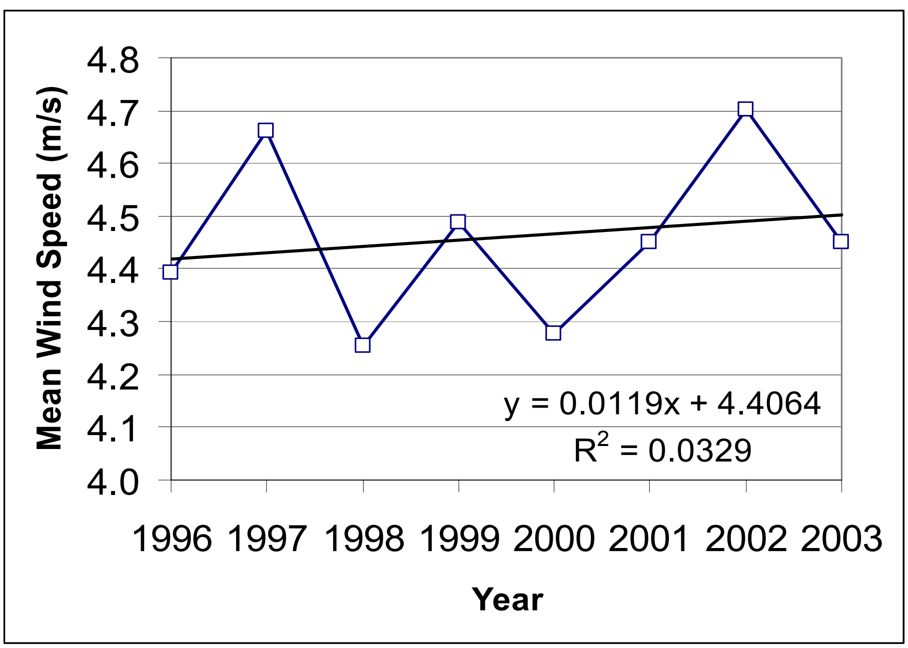
ISG 48.4 m Wind Speed = Buffalo 10 m speed * 1.7063 - 0.5093 m/s.

The r-squared values ranged from 0.89 to 0.94, suggesting excellent correlation between the monitoring sites and the Buffalo Airport reference station.

The Buffalo Airport station annual mean wind speeds were examined to determine if any significant trends occurred during the period of record. Such trends could indicate changing climatological conditions around the reference station or others such as tree growth or clearing, building construction or demolition, or problems with equipment. Any discontinuities in the long-term dataset would introduce potentially significant errors into the long-term adjustment of site data. To limit that risk, stations showing significant trends are generally avoided, unless the trends can be confirmed by data from other stations. Figure 6 contains a plot of the Buffalo airport annual mean wind speeds along with a linear trend line illustrating the wind speed change over time.

The reference data show no significant trends as evidenced by the small slope in the trend line (slope ~ 0.01) and an r-squared value near zero. Unfortunately, the short post-ASOS period of record limits the ability to measure long-term climatological trends at the site.

Figure 6. Buffalo Airport Annual Mean Wind Speeds



From 1996 to 2003, the Buffalo Airport long-term mean wind speed was 4.46 m/s. This value was substituted into the regression equation for each monitoring tower to estimate the respective site long-term mean wind speeds. Table 3 summarizes those long-term estimates.

Table 3. Monitoring Site Long-Term Wind Speed Estimates

Monitoring Site	Long-Term Mean Wind Speed (m/s)
NFTA	7.63 (110 m)
GM	5.41 (48.8 m)
CSX	5.76 (48.4 m)
ISG	7.10 (48.4 m)
Southtowns	6.87 (60 m)

Estimating the Southtowns sodar site long-term mean wind speed involved application of a different methodology because of the short period of record (~ 1 month). During the sodar period of record, ratios of the directional mean wind speeds were computed between Southtowns (60 m) and NFTA (59.5 m). These values were then used to scale the NFTA 59.5 m long-term directional wind speed estimates to equivalent values at Southtowns. The NFTA 59.5 m long-term wind speed was determined through a separate regression with the Buffalo Airport. Since the wind roses at Southtowns and NFTA were similar during the concurrent periods of record, a weighted-average using the scaled 60 m wind speeds at Southtowns and the NFTA directional frequency distribution was computed to estimate the long-term mean wind speed. The result of this method yields a slight downward adjustment to the mean wind speed reported in the previously issued 12-month summary table. This is because a modification was made to the long-term weighting procedure where previously, the overall mean wind speed at NFTA was used.

Uncertainty in Wind Speed Estimates

For the monitoring site 80 m long-term wind speed estimates, we estimate roughly ± 3.5 % uncertainty. This figure accounts for uncertainties associated with anemometer accuracy (± 1.5 %), the long-term representativeness of the monitoring period wind speeds at both the monitoring sites and the Buffalo Airport reference station (± 3.0 %), and the accuracy of the wind shear interpolations/extrapolations from monitoring height to hub height (± 1.0 %). The excellent correlations between monitoring sites and the reference station played a major role in minimizing the uncertainties in the long-term estimates.

Validation of New York State Wind Map in Western New York

In 2000, AWS Truewind created a New York State wind map with support from NYSERDA. This map used the MesoMap system developed by AWS Truewind. A mesoscale model called MASS – Mesoscale Atmospheric Simulation System – was first run over the state at a resolution of 5 km. The MASS model wind statistics were then input into WindMap, a fast three-dimensional wind flow model, which produced 65 m and 100 m (above ground level) wind speed estimates at a grid scale resolution of 400 m.

Since the creation of the 400 m resolution New York wind map, additional data and computational abilities have allowed AWS Truewind to revise and improve the map. Part of the improvement is due to the use of additional high quality datasets – like the Buffalo Shoreline Wind Study – to validate the map. Also, the map resolution has been improved at the MASS level from 5 to 2 km, and at the WindMap level from 400 m to 200 m. Tables 4, 5, and 6 illustrate how well the 200 m wind map validates with the wind speed measurements from this study.

Table 4 illustrates the map validation statistics at 65 m above ground. The standard deviation of the differences between the measured and predicted wind speeds is 2.4 %, which is less than the uncertainty in the long-term wind speed predictions based on the measured data (3.5 %). This means the wind map is predicting the wind resource with accuracy comparable to measurements.

Table 4. Comparison of Measured and Predicted 65 m Wind Speeds

Site	Measured Wind Speed (m/s)	200 m Map Resolution	
		Predicted Wind Speed (m/s)	Measured Minus Predicted
NFTA	6.92	7.06	-0.14
GM	5.81	6.03	-0.22
CSX	6.13	6.38	-0.25
ISG	7.48	7.41	0.07
Southtowns	6.96	6.88	0.08
Average (m/s):	6.66	6.75	-0.09
Average (%):			-1.4 %
Standard Deviation (m/s):			0.16
Standard Deviation (%):			2.4 %

Table 5 shows the measured and predicted 80 m wind speeds – a typical hub height for modern wind turbines. Both the measured and predicted wind speeds are higher, as expected, but the predicted values have increased more rapidly than the measured. The discrepancy at the CSX tower in particular has increased from 0.25 m/s to 0.41 m/s. This could indicate that the model wind shear is too high at this mast, or that the assumption of constant shear with height above the mast is not correct.

Table 6 shows a continuing pattern at 100 m. The discrepancy has increased to 0.59 m/s at CSX. The ISG site appears to be well estimated; however this tower is relatively well exposed on a lakeside bluff, and thus may not be typical of the area as a whole. At the other towers and at the sodar site, the discrepancy ranges from 0.23 to 0.35 m/s. The evidence of a discrepancy at NFTA and Southtowns in particular is telling, because the winds were measured at both locations to above 100 m. The average difference between the map and measurement has increased from 1.4 % at 65 m to 3.9 % at 100 m. However, the standard deviation remains relatively low at 0.22 m/s, or 3 %, indicating that the map continues to predict the variation in speed among the sites with high accuracy.

Table 5. Comparison of Measured and Predicted 80 m Wind Speeds

Site	Measured Wind Speed (m/s)	200 m Map Resolution	
		Predicted Wind Speed (m/s)	Measured Minus Predicted
NFTA	7.20	7.38	-0.18
GM	6.11	6.38	-0.27
CSX	6.41	6.82	-0.41
ISG	7.75	7.71	0.04
Southtowns	7.20	7.29	-0.09
Average (m/s):	6.93	7.12	-0.19
Average (%):			-2.7 %
Standard Deviation (m/s):			0.17
Standard Deviation (%):			2.5 %

Table 6. Comparison of Measured and Predicted 100 m Wind Speeds

Site	Measured Wind Speed (m/s)	200 m Map Resolution	
		Predicted Wind Speed (m/s)	Measured Minus Predicted
NFTA	7.49	7.72	-0.23
GM	6.45	6.80	-0.35
CSX	6.72	7.31	-0.59
ISG	8.06	8.04	0.02
Southtowns	7.46	7.73	-0.27
Average (m/s):	7.24	7.52	-0.28
Average (%):			3.9 %
Standard Deviation (m/s):			0.22
Standard Deviation (%):			3.0 %

Overall it appears the map is relatively accurate at 65 m in this area, but because the predicted wind shear is slightly higher than the measured, it is about 0.3 m/s (4 %) too high at 100 m.

Energy Production Estimates

The energy production at each respective monitoring site was calculated using five commercially available wind turbine models ranging in size from 1.5 MW to 2.3 MW. Appendix 2 provides detailed monitoring site summaries containing the rated power, the estimated annual gross and net energy production for an 80 m hub height (100 m is also included for GE 2.3 MW turbine because it's not available at 80 m), and the gross and net capacity factors for each turbine model.

For each site, the 12-month dataset was scaled to the estimated long-term mean wind speed and interpolated/extrapolated to hub height. Diurnal wind shear distributions were computed and applied to the measurement height mean winds to compute the hub height wind speed distributions. Frequency distributions were then calculated and normalized to a full calendar year (8,760 hours). Each site's estimated energy potential was computed by combining the wind speed frequency distribution with the appropriate power curve for each turbine model. The power curves were adjusted to the each site's specific energy-weighted site air density.

When assessing the turbine performance for a potential project at any of these sites, it may be somewhat misleading to focus on the energy production of each turbine model because of their different nameplate capacities. In this instance, comparing the turbine-specific net capacity factors can provide a more accurate performance assessment because respective one-turbine samples are being tested. If multiple-turbine projects – each totaling identical capacities – were sampled, it would then be beneficial to consider the energy production as well.

A broad range of net capacity factors was observed at the four monitoring sites. The highest capacity factors (between 35 % and 37 %) were recorded at the ISG site, while the lowest values (between 22 % and 25.5 %) were observed at GM. Overall, the general signature is that the coastal sites (NFTA and ISG) exhibited much higher net capacity factors (and net energy production) than those that were located further inland (GM and CSX). This is most likely due to surface roughness effects.

Summary

A 12-month wind resource assessment involving four monitoring towers and a sodar site was recently completed along the eastern Lake Erie shoreline near Buffalo, NY. Average wind speeds were observed to drop quickly less than 2 km inland, as surface roughness effects appeared to play a major role in affecting the wind resource at each respective monitoring site.

The wind speed estimates computed in the Buffalo Shoreline Wind Study were compared with the most recent New York state wind map and they show that the map validates well with the measurements. The uncertainty associated with the map predictions is approximately equal to the uncertainty associated with long-term wind speed estimates based on wind measurements.

The energy production varied substantially across the monitoring area in accordance with the observed spatial wind speed profile. The coastal sites suggest net capacity factors between 31 % and 37 % depending on the site and wind turbine model, while the inland sites indicated substantially lower net capacity factors between 22 % and 28 %. The data suggest that proximity to the Lake Erie coastline is an essential factor to consider should wind energy development be considered in the region.

Appendix A:

Pictures of Wind Monitoring Sites and Surrounding Areas

Figure A1. Picture of NFTA Tower Looking Approximately West

* Note: The object to the left of the tower is an airborne helicopter behind the tower.

Figure A2. Picture of 50 m Tubular Tower Used at GM, CSX, and ISG

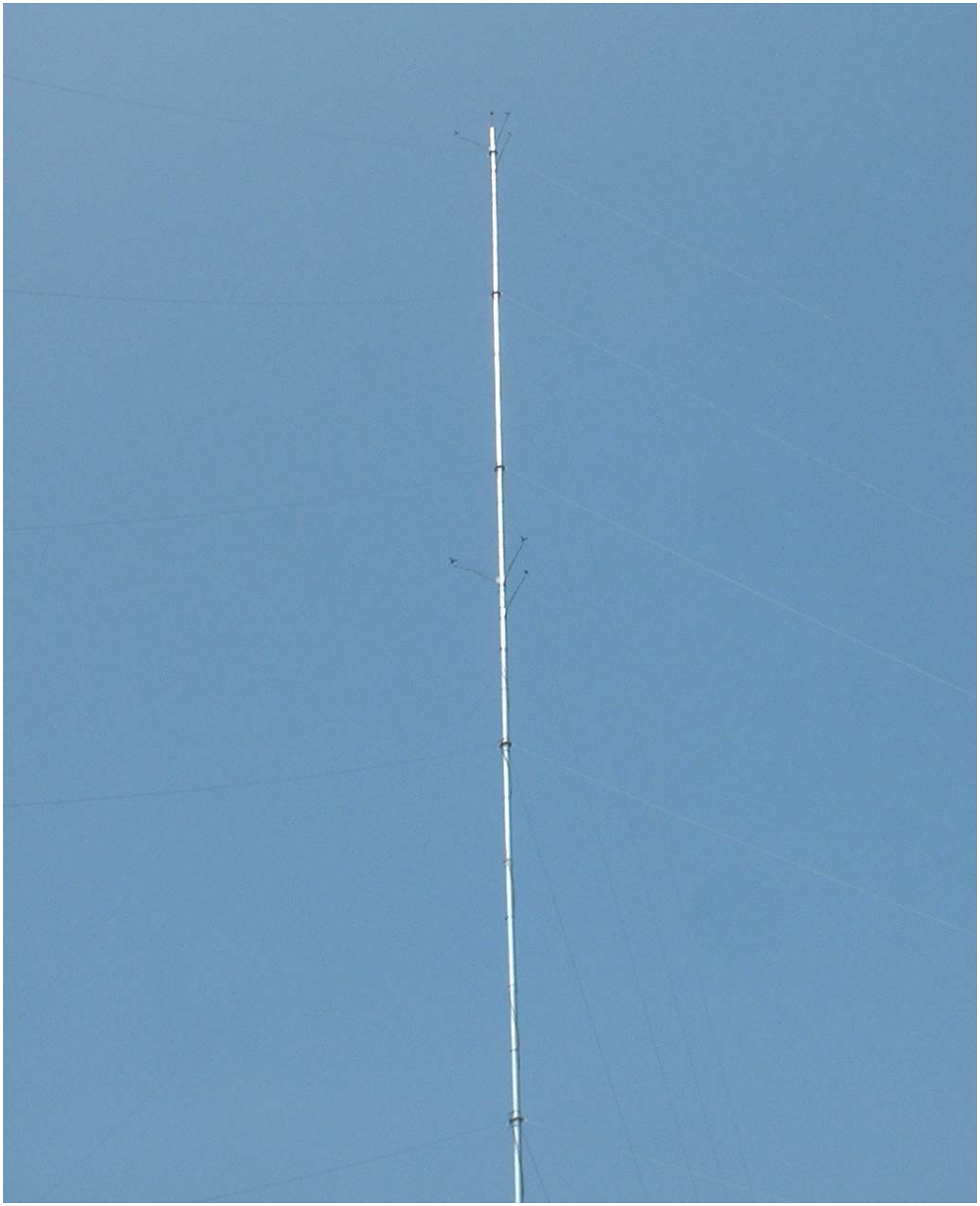


Figure A3. Picture at GM Tower Looking Approximately West

Figure A4. Picture at CSX Tower Looking Approximately West

Figure A5. Picture at ISG Tower Looking Approximately West

Figure A6. Picture at Southtowns Sodar Site Looking Approximately Southwest

Appendix B:

Monitoring Site Energy Production and Turbine Performance Reports

Figure B1. Energy Output and Turbine Performance for NFTA

General Site Information

Site Name	NFTA Tower
Location	Eastern Shore of Lake Erie
Lat / Long (deg N / deg W)	42° 31' 23.4" / 78° 52' 19.2"
Data Period	June 2003 - May 2004
Site Elevation (m)	172

Turbine Data	**Units**						
Turbine model		**GE 1.5 / 77 m**	**GE 1.5 / 82.5 m**	**Vestas V-82**	**Gamesa G-87**	**GE 2.3 MW**	**GE 2.3 MW**
Nameplate capacity	kW	1500	1500	1650	2000	2300	2300
Hub height	m	80	80	80	80	80	100
Rotor diameter	m	77	82.5	82	87	94	94

Energy Output Data	**Units**						
Turbine model		**GE 1.5 / 77 m**	**GE 1.5 / 82.5 m**	**Vestas V-82**	**Gamesa G-87**	**GE 2.3 MW**	**GE 2.3 MW**
Average Wind Speed	m/s	7.20	7.20	7.20	7.20	7.20	7.49
Average Air Density	kg/m^3	1.22	1.22	1.22	1.22	1.22	1.22
Gross Annual Energy Production	MWh	4784	5111	5282	6301	7224	7671
Gross Capacity Factor	%	36.4%	38.9%	36.5%	36.0%	35.9%	38.1%
Percent Energy Loss	%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%
Net Annual Energy Production	MWh	4210	4498	4649	5545	6357	6751
Net Capacity Factor	%	32.0%	34.2%	32.2%	31.7%	31.6%	33.5%

AWS Truewind

Figure B2. Energy Output and Turbine Performance for GM

General Site Information

Site Name	GM Tower
Location	Eastern Shore of Lake Erie
Lat / Long (deg N / deg W)	42^o 58' 14.9" / 78^o 54' 34.0"
Data Period	September 2003 - August 2004
Site Elevation (m)	178

Turbine Data	**Units**						
Turbine model		**GE 1.5 / 77 m**	**GE 1.5 / 82.5 m**	**Vestas V-82**	**Gamesa G-87**	**GE 2.3 MW**	**GE 2.3 MW**
Nameplate capacity	kW	1500	1500	1650	2000	2300	2300
Hub height	m	80	80	80	80	80	100
Rotor diameter	m	77	82.5	82	87	94	94

Energy Output Data	**Units**						
Turbine model		**GE 1.5 / 77 m**	**GE 1.5 / 82.5 m**	**Vestas V-82**	**Gamesa G-87**	**GE 2.3 MW**	**GE 2.3 MW**
Average Wind Speed	m/s	6.11	6.11	6.11	6.11	6.11	6.45
Average Air Density	kg/m^3	1.22	1.22	1.22	1.22	1.22	1.22
Gross Annual Energy Production	MWh	3428	3796	3836	4481	5099	5715
Gross Capacity Factor	%	26.1%	28.9%	26.5%	25.6%	25.3%	28.4%
Percent Energy Loss	%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%
Net Annual Energy Production	MWh	3016	3340	3376	3944	4487	5029
Net Capacity Factor	%	23.0%	25.4%	23.4%	22.5%	22.3%	25.0%

AWS Truewind

Figure B3. Energy Output and Turbine Performance for CSX

General Site Information

Site Name	CSX Tower
Location	Eastern Shore of Lake Erie
Lat / Long (deg N / deg W)	42^o 50' 19.4" / 78^o 50' 39.4"
Data Period	September 2003 - August 2004
Site Elevation (m)	174

Turbine Data	**Units**						
Turbine model		**GE 1.5 / 77 m**	**GE 1.5 / 82.5 m**	**Vestas V-82**	**Gamesa G-87**	**GE 2.3 MW**	**GE 2.3 MW**
Nameplate capacity	kW	1500	1500	1650	2000	2300	2300
Hub height	m	80	80	80	80	80	100
Rotor diameter	m	77	82.5	82	87	94	94

Energy Output Data	**Units**						
Turbine model		**GE 1.5 / 77 m**	**GE 1.5 / 82.5 m**	**Vestas V-82**	**Gamesa G-87**	**GE 2.3 MW**	**GE 2.3 MW**
Average Wind Speed	m/s	6.41	6.41	6.41	6.41	6.41	6.72
Average Air Density	kg/m^3	1.23	1.23	1.23	1.23	1.23	1.23
Gross Annual Energy Production	MWh	3867	4220	4319	5069	5778	6289
Gross Capacity Factor	%	29.4%	32.1%	29.9%	28.9%	28.7%	31.2%
Percent Energy Loss	%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%
Net Annual Energy Production	MWh	3403	3714	3801	4461	5084	5535
Net Capacity Factor	%	25.9%	28.3%	26.3%	25.5%	25.2%	27.5%

AWS Truewind

Figure B4. Energy Output and Turbine Performance for ISG

General Site Information

Site Name	ISG Tower
Location	Eastern Shore of Lake Erie
Lat / Long (deg N / deg W)	42^o 49' 12" / 78^o 52' 6.8"
Data Period	September 2003 - August 2004
Site Elevation (m)	181

Turbine Data	**Units**						
Turbine model		**GE 1.5 / 77 m**	**GE 1.5 / 82.5 m**	**Vestas V-82**	**Gamesa G-87**	**GE 2.3 MW**	**GE 2.3 MW**
Nameplate capacity	kW	1500	1500	1650	2000	2300	2300
Hub height	m	80	80	80	80	80	100
Rotor diameter	m	77	82.5	82	87	94	94

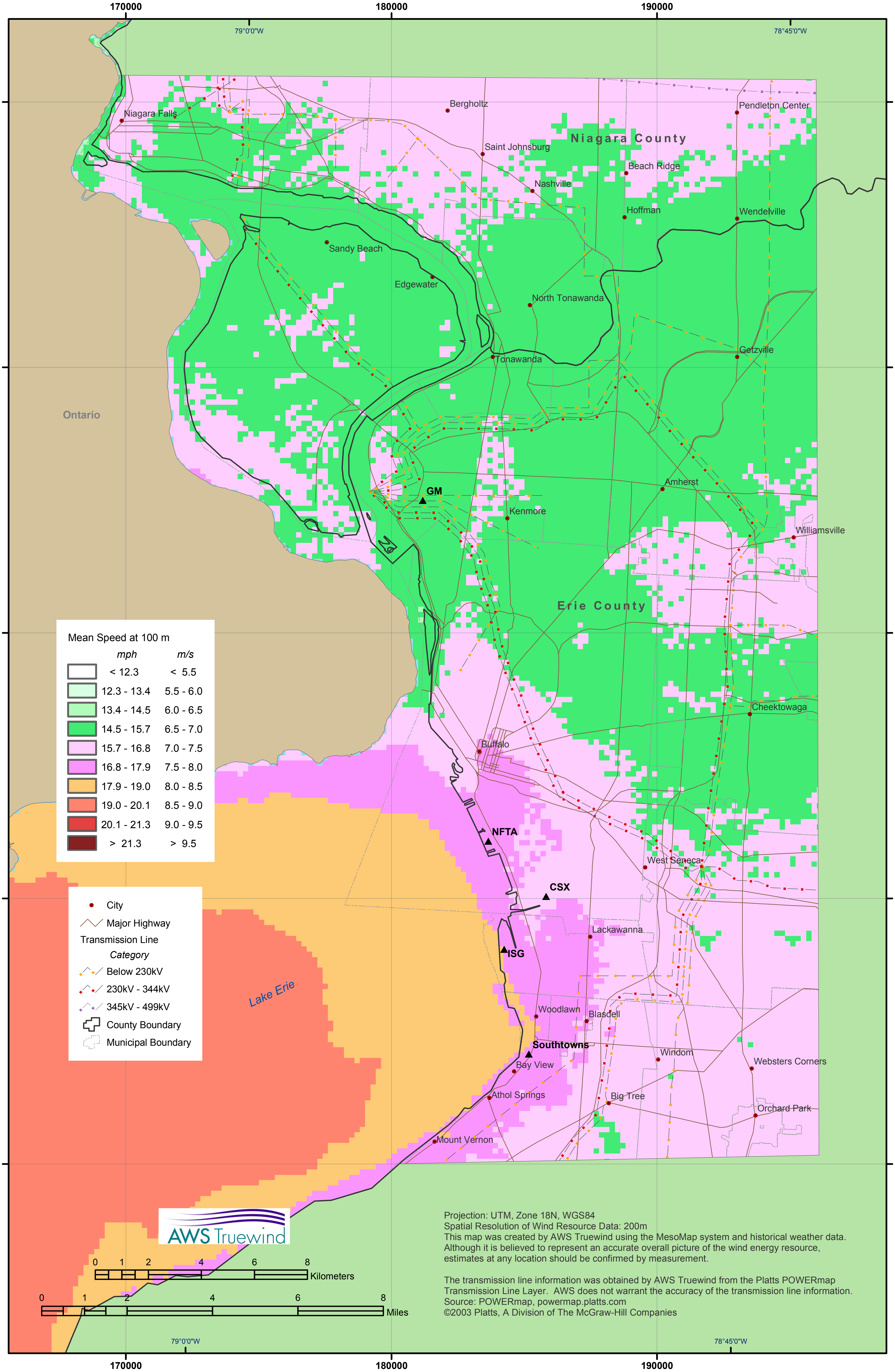
Energy Output Data	**Units**						
Turbine model		**GE 1.5 / 77 m**	**GE 1.5 / 82.5 m**	**Vestas V-82**	**Gamesa G-87**	**GE 2.3 MW**	**GE 2.3 MW**
Average Wind Speed	m/s	7.75	7.75	7.75	7.75	7.75	8.06
Average Air Density	kg/m^3	1.23	1.23	1.23	1.23	1.23	1.23
Gross Annual Energy Production	MWh	5267	5476	5711	6969	7982	8426
Gross Capacity Factor	%	40.1%	41.7%	39.5%	39.8%	39.6%	41.8%
Percent Energy Loss	%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%
Net Annual Energy Production	MWh	4635	4819	5026	6133	7024	7415
Net Capacity Factor	%	35.3%	36.7%	34.8%	35.0%	34.9%	36.8%

AWS Truewind

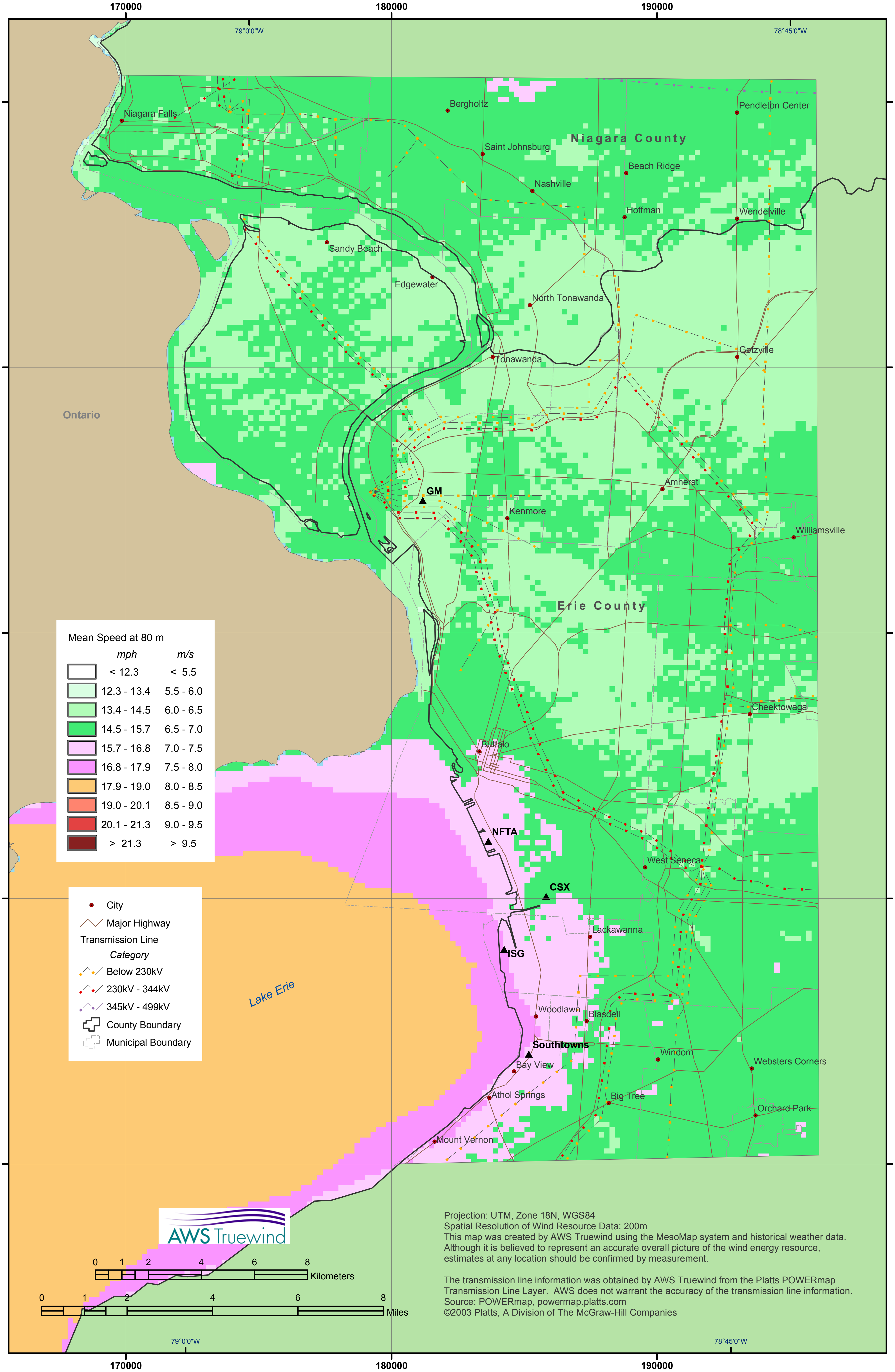
APPENDIX F

WIND RESOURCES MAPS

Wind Speed of Western New York at 100 Meters



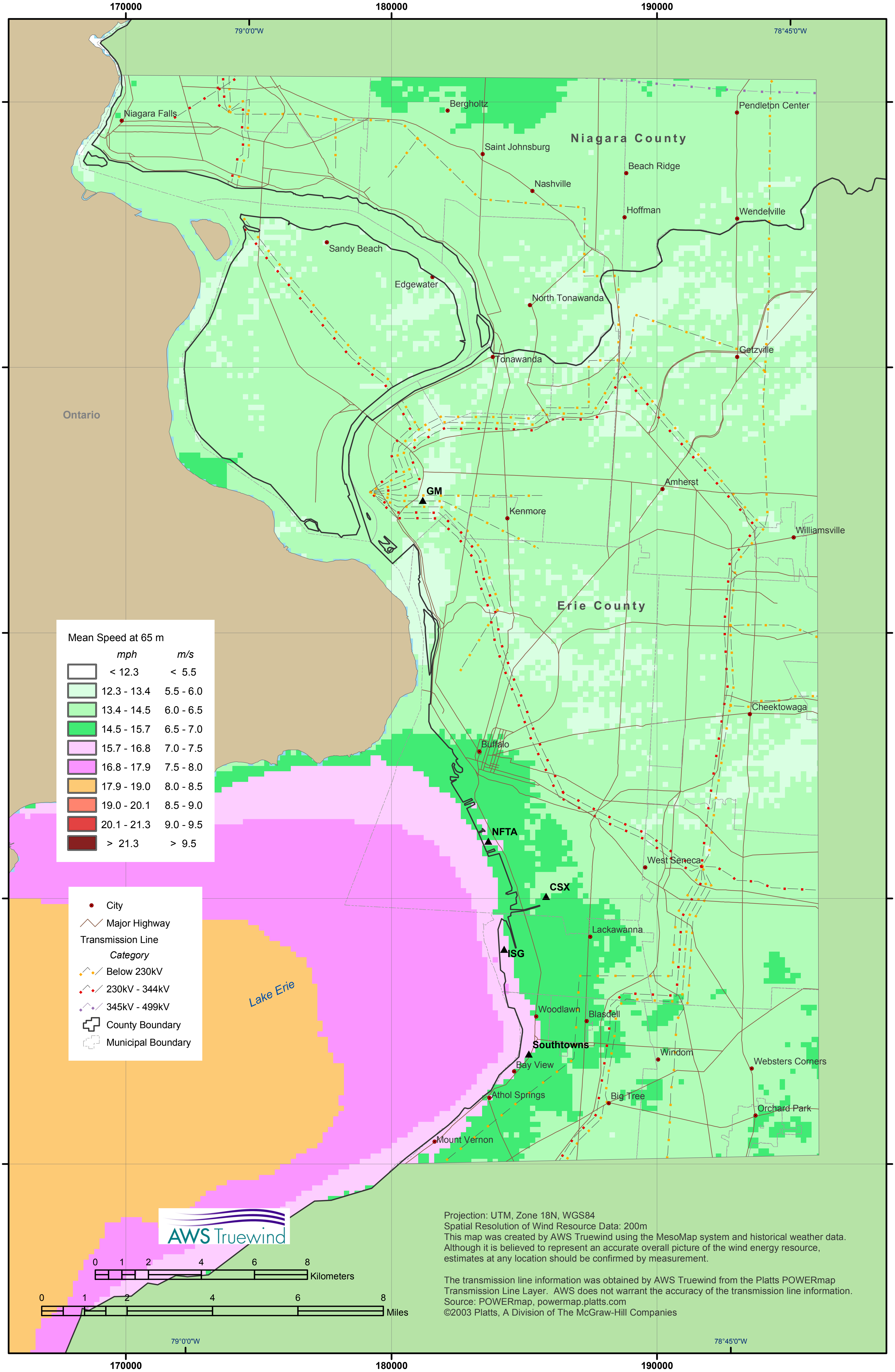
Wind Speed of Western New York at 80 Meters



Projection: UTM, Zone 18N, WGS84
Spatial Resolution of Wind Resource Data: 200m
This map was created by AWS Truewind using the MesoMap system and historical weather data. Although it is believed to represent an accurate overall picture of the wind energy resource, estimates at any location should be confirmed by measurement.

The transmission line information was obtained by AWS Truewind from the Platts POWERmap Transmission Line Layer. AWS does not warrant the accuracy of the transmission line information.
Source: POWERmap, powermap.platts.com

Wind Speed of Western New York at 65 Meters



Projection: UTM, Zone 18N, WGS84
Spatial Resolution of Wind Resource Data: 200m
This map was created by AWS Truewind using the MesoMap system and historical weather data. Although it is believed to represent an accurate overall picture of the wind energy resource, estimates at any location should be confirmed by measurement.

The transmission line information was obtained by AWS Truewind from the Platts POWERmap Transmission Line Layer. AWS does not warrant the accuracy of the transmission line information.
Source: POWERmap, powermap.platts.com

APPENDIX G

FEDERAL AVIATION ADMINISTRATION CORRESPONDENCE

918-437-8659-

Federal Aviation Administration
Eastern Regional Office
1 Aviation Plaza-AEA-520
Jamaica, NY 11434

Aeronatucial Study No.
2003-AEA-1457-OE
Prior Study No.
-AEA--OE

Issued Date: 5/22/2003

MARK MITSKOVSKI
ERIE CNTY DEPT OF ENVIRONMENT & PLANNING
95 FRANKLIN ST
BUFFALO, NY 14202

**** DETERMINATION OF PRESUMED HAZARD ****

The Federal Aviation Administration has conducted an aeronautical study under the provisions of 49 U.S.C., Section 44718 and if applicable Title 14 of the Code of Federal Regulations, part 77, concerning:

Structure Type:	METEOROLOGICAL TOWER
Location:	LACKAWANNA, NY
Latitude:	42-47-6.54 NAD 83
Longitude:	78-50-57.84
Heights:	146 feet above ground level (AGL)
	734 feet above mean sea level (AMSL)

The initial findings of this study indicated that the structure as described above would exceed obstruction standards and/or would have an adverse physical or electromagnetic interference effect upon navigable airspace or air navigation facilities. Therefore, pending resolution of the issues described below, it is hereby determined that the structure is presumed to be a hazard to air navigation.

If the structure were reduced in height so as not to exceed 120 feet above ground level (708 feet above mean sea level), it would not exceed obstruction standards and a favorable determination could subsequently be issued.

To pursue the possibility of a favorable determination at the originally submitted height, further study would be necessary. Further study entails circularization to the public for comment. This process requires approximately 90 to 120 days from the date that further study is requested before any subsequent determination would be effective. The outcome cannot be predicted prior to public circularization.

Further study may be requested by the sponsor within 60 days of the date of this letter.

A copy of this determination will be forwarded to the Federal Communications Commission if the structure is subject to their licensing authority.

NOTE: PENDING RESOLUTION OF THE ISSUES DESCRIBED ABOVE, THE STRUCTURE IS PRESUMED TO BE A HAZARD TO AIR NAVIGATION. THIS DETERMINATION DOES NOT AUTHORIZE CONSTRUCTION OF THE STRUCTURE EVEN AT A REDUCED HEIGHT. ANY RESOLUTION OF THE ISSUES DESCRIBED ABOVE MUST BE COMMUNICATED TO THE FAA SO THAT A FAVORABLE DETERMINATION CAN SUBSEQUENTLY BE ISSUED.

IF MORE THAN 60 DAYS FROM THE DATE OF THIS LETTER HAS ELAPSED WITHOUT ATTEMPTED RESOLUTION, IT WILL BE NECESSARY FOR YOU TO REACTIVATE THE STUDY BY FILING A NEW FAA FORM 7460-1, NOTICE OF PROPOSED CONSTRUCTION OR ALTERATION.

If we can be of further assistance, please contact our office at (718)553-4546. On any future correspondence concerning this matter, please refer to Aeronautical Study Number 2003-AEA-1457-OE.

Robert P Alexander

Robert P. Alexander
Specialist

(DPH) 178680

Post-it® Fax Note 7671	Date	# of pages ▶ 2
To O. Wegand	From M2	
Co./Dept.	Co.	
Phone #	Phone #	
Fax # 684-0844	Fax #	

APPENDIX H
AVIAN ANALYSIS

Ecology & Environment, Inc.

Memo

To: Kevin Neumaier

From: Mike Morgante

CC: Deepali Weyand

Date: 1/10/05

Re: Erie County Shoreline Wind Study Sites: Brief and Basic Avian Analysis

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As requested, here is a short description of the avian use at or near each of the five wind study sites. No site visits or surveys were conducted as part of this effort.

General

The five wind study sites are located in relatively close proximity to each other. All of the sites are located at urban settings in Erie County near Lake Erie or the Niagara River. There is some general avian information that describes the collective locations of the sites.

The urban and industrial settings provide poor quality habitat for most bird species. A relatively low abundance and diversity of birds would be expected at the actual site locations due to the poor habitat. However, there are several areas in relatively close proximity to the five wind study sites that are well known for birding.

Two of these areas, the Niagara River and Tifft Nature Preserve, have been classified by Audubon New York as 'Important Bird Areas' (IBAs) (Wells 1998). IBAs are recognized for providing essential habitat to birds. There are several criteria for site selection but are generally attributed to the presence of threatened/endangered species or large concentrations of birds during the breeding, migratory, and/or winter season. The IBA designation does not offer any additional legal protection or limitations, however, it is a clear identification of an area with conservation concerns from the public, NGOs, and agencies. Beyond the Audubon New York list, the Niagara River IBA is a globally recognized IBA and is included as one of the top 500 IBAs in the United States by the American Bird Conservancy (American Bird Conservancy 2003). The Niagara River Corridor IBA is recognized primarily for its stopover and wintering habitat for large concentrations of waterfowl and gulls. Tifft Nature Preserve is recognized as an important stopover site during migration and a high diversity of bird species (over 260 recorded at the site), including some threatened and endangered species.

While not categorized as IBAs, there are several other prominent birding areas in the proximity of the five wind study sites. Times Beach Nature Preserve and Woodlawn Beach State Park are well known as popular birding areas and over 230 and 160 species have been documented at these locations, respectively. Public funding has been used to improve access for birding at both of these areas in recent years.

The breakwalls at the Buffalo waterfront and islands on the Niagara River provide excellent breeding habitat for colonial nesting waterbirds (e.g. gulls, terns, herons, cormorants). The presence and proximity of these colonies will likely be a consideration during avian review at several of these study sites. There is considerable waterfowl use and migration on the Niagara River and Lake Erie, however, this use is primarily limited to the actual water bodies and not the adjacent land.

Raptors are known to avoid flying over large bodies of water during migration. Therefore, raptors concentrate along the southern shores of the Great Lakes during spring migration and the northern shores of the Great Lakes during fall migration. The five study sites are at or near the northeast 'end' of Lake Erie and the associated spring raptor migration pathway. During the spring migration season (typically mid-March through mid-May), especially during winds with a strong easterly component, migrating raptors may fly directly over the sites. The Hamburg Hawkwatch, located on Camp Road in the Town of Hamburg several miles southeast of the SSTF site, is the closest raptor monitoring location. Nearly 12,000 raptors were tallied during the spring migration in 2004 at the Hawkwatch. The five study sites are in areas that do not provide significant migratory stopover habitat due to their urban settings. However, land with appropriate habitat adjacent to Lake Erie and Niagara River may be considered as important for migratory stopover use by songbirds. There is some evidence that songbirds also demonstrate some lake avoidance during their nocturnal migration.

There are several birding groups that are active in the area. The most prominent are the Buffalo Ornithological Society and Buffalo Audubon Society. Both of these groups, as well as other conservation groups, would likely be interested in learning the details of any proposed wind projects on the Buffalo Waterfront. Due to the recent scrutiny of proposed wind projects by the public, NGOs, and regulatory agencies, it is likely that there would be individuals and groups that express avian concerns for these (and any other proposed) wind farm sites, regardless of the poor habitat at the site locations.

The New York State Breeding Bird Atlas ("Atlas 2000") is a mostly volunteer effort to record evidence of breeding bird species throughout the State, as divided into 5-km by 5-km blocks. The data provide evidence of breeding composition and quality of breeding habitat. A minimum of 76 total species is the goal for each block, although this goal is often not possible in blocks that are primarily urban or industrial. Draft data of the Atlas 2000 project are provided in the descriptions for each of the five wind study sites below.

<u>NFTA Site</u>

The setting at this industrial site generally provides poor quality habitat for most bird species. A relatively low abundance and diversity of birds would be expected at the actual site due to the poor habitat existing there.

The NFTA site is located along the Buffalo Outer Harbor in close proximity to two prominent birding areas. Times Beach Nature Preserve is at the north end of the Buffalo Outer Harbor and Tifft Nature Preserve is located to the southeast of the NFTA site across Route 5.

The NFTA Site is located in atlas block 1775D, which also includes Times Beach Nature Preserve and a portion of Tifft Nature Preserve. Draft data through the 2004 season indicate 78 total species have been documented as possible, probable, or confirmed breeders in the block, including two state-threatened species (Pied-billed Grebe and Least Bittern) that are known to nest at Tifft Nature Preserve (NYSDEC web site accessed 1/10/05).

<u>General Motors (GM) Site</u>

The setting at this industrial site generally provides poor quality habitat for most bird species. A relatively low abundance and diversity of birds would be expected at the actual site due to the poor habitat existing there.

The GM Site is located just east of the Niagara River, including Motor Island and Strawberry Island. These two islands provide sensitive nesting habitat to numerous colonial nesting waterbirds. NYSDEC documents the nesting activity on an annual basis.

The GM Site is located in atlas block 1776D, which includes a portion of Strawberry Island. Draft data through the 2004 season indicate 50 total species have been documented as possible, probable, or confirmed breeders in the block (NYSDEC web site accessed 1/10/05).

CSX Corporation Site

The setting at this industrial site generally provides poor quality habitat for most bird species. A relatively low abundance and diversity of birds would be expected at the actual site due to the poor habitat existing there.

The CSX site is located south of Tifft Nature Preserve. It is located in atlas block 1874A. Draft data through the 2004 season indicate 56 total species have been documented as possible, probable, or confirmed breeders in the block (NYSDEC web site accessed 1/10/05).

International Steel Group (ISG) Site

The setting at this industrial site generally provides poor quality habitat for most bird species. A relatively low abundance and diversity of birds would be expected at the actual site due to the poor habitat existing there.

The ISG site is located in atlas block 1774B. Draft data through the 2004 season indicate 39 total species have been documented as possible, probable, or confirmed breeders in the block (NYSDEC web site accessed 1/10/05). There is a very large nesting colony of Ring-billed and Herring Gulls located on the ISG site along the Buffalo Outer Harbor.

Southtowns Sewage Treatment Facility (SSTF)

The setting at this industrial site generally provides poor quality habitat for most bird species. A relatively low abundance and diversity of birds would be expected at the actual site due to the poor habitat existing there.

The SSTF site is located adjacent to Woodlawn Beach State Park and Lake Erie and is several miles northwest of the Hamburg Hawkwatch monitoring location.

The site is located in atlas block 1874C. Draft data through the 2004 season indicate 63 total species have been documented as possible, probable, or confirmed breeders in the block (NYSDEC web site accessed 1/10/05).

References:

American Bird Conservancy. 2003. The American Bird Conservancy Guide to the 500 Most Important Bird Areas in the United States. Random House. New York.

NYSDEC breeding bird atlas web page (http://www.dec.state.ny.us/apps/bba/results/), site accessed 1/10/05.

Wells, J.V. 1998. Important Bird Areas in New York State. National Audubon Society of New York. Albany.

APPENDIX I

NEW YORK STATE RENEWABLE PORTFOLIO STANDARD KEY PROVISIONS

NEW YORK STATE RENEWABLE PORTFOLIO STANDARD
KEY PROVISIONS

Timeline and Megawatt Hour goals for compliance

- NYSERDA will begin procurement for RPS in late 2005 or early 2006, with 2006 as the "start" date for the RPS
- The objective is to acquire enough renewable generation such that renewable energy will constitute 25% of retail electric sales in NY by 2013; approximately 19% of the State's energy sales are currently from renewables; therefore the RPS will increase renewable use by approximately 6%;
- Add generation through gradual % increases (approximately 1% per year) which will result in the addition of just under 12 gigawatt hours in renewable generation between now and 2013;
- The State will need about 3,700 MW to meet the goal, the majority of it from wind energy.

Procurement Method

- The majority of new renewable generation to come from a "centrally-administered, incentive-based procurement mechanism" via a NYSERDA-run program using funds from a non-bypassable wires charge on ratepayer bills
- 1% (of the overall 25% goal) to be achieved through the voluntary green energy market
- Customers who are currently exempt from System Benefits Charge will not have to contribute to costs of the RPS through their rates funding (i.e., "flex-rate," municipals, NYPA economic development customers)

Timeline for implementation

- NYSERDA and the Department of Public Service staff must develop an implementation plan by the end of March of 2005; the plan will be issued for public comment and Commission approval
- In order to meet the March deadline, NYSERDA wants to have a plan ready for review by the end of 2004
- Utilities are directed to begin collecting funds in ratepayer bills in the fourth quarter of 2005
- Utilities directed to enter into contracts or agreements with NYSERDA, adjust their tariffs and billing and accounting systems, etc. within specified time periods.

Eligibility

- Only new renewable generation is eligible for the RPS with "new" defined as commencing operation after Jan. 2003;
- Certain existing resources (wind, hydro less than 5 MW and biomass plants) may petition for eligibility based on economic need;

- Other eligible technologies include fuel cells, photovoltaics, certain hydropower projects (upgrades and low-impact, run-of-river projects less than 30 MW), and specific forms of biogas and biomass;

- New/emerging behind the meter/customer-sited technologies (fuel cells, photovoltaics, and wind of 300 kw or less) to have a special “tier” of 2% of the incremental six percent needed to fulfill the goal;

- No project may receive SBC incentives after that project begins to participate in the RPS program.

Contract Provisions

- Acknowledges that renewable energy projects need long-term contracts to secure financing;

- States that RPS participation is available to all eligible generators scheduling into the NYISO controlled markets except those using certain “physical” bilateral contracts wherein the right to the energy is directly transferred to a particular load-serving entity. Purely financial hedge contracts are acceptable.

Renewable Energy Credit Tracking and Trading

- None at this time. The PSC chose to maintain New York’s Conversion Transaction system at this time.

Imports and Energy Delivery Requirements

- Imports from eligible technologies located out of state are eligible, providing there is a documented delivery of energy into New York.

- Monthly matching of energy deliveries is required.

- If the exporting system has an attributes tracking system or environmental disclosure program, the system must be able to recognize the monthly matching without “double-counting” the renewable energy.

- Recommends evaluation and possible reconsideration of the delivery requirement during the review recommended for 2009.

Costs of the Program

- The costs are said to be modest or minimal: cumulative cost of premium payments predicted to be between $582 million to $762 million offset by a $362 million reduction in wholesale energy prices. The net present value of the program is estimated at between $179 million to $323 million.

- Modest bill impacts (taking impact on wholesale prices and fuel costs into consideration): -0.9% to +1.68% for residential customers; -0.78% to +1.79% for commercial customers; and –1.54% to +2.20% for industrial customers.

- The initial wires charge to be levied by each utility are included in the Order, with annual reconciliation of amounts collected versus funds needed.

Reliability

- States that system reliability is of the utmost importance and therefore the implementation phase should be flexible enough to accommodate modifications if any are found necessary. The Order does reiterate the findings of the Phase 1 Study on Wind Integration, which found that the addition of 3,300 MW of wind should pose no system reliability problems.

- Directs staff to review (in consultation with NYISO and NYSRC) the Phase 2 report of the Wind Integration Study and within 60 days if its issuance report on any modifications to the RPS needed to ensure system reliability.